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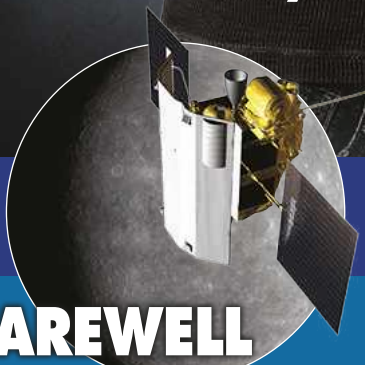

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MARCH 2015 #118
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This month's contributors include...

PETE LAWRENCE
SKY AT NIGHT PRESENTER

Our *Sky Guide* author explains the timings for the eclipse and gives his advice on photographing the event. *Pages 50 & 60*

DANIEL LYNCH
SOLAR ECLIPSE CHASER

Daniel has been chasing eclipses since 1999. He sets out how he edits his totality shots to bring out the Sun's chromosphere. *Page 85*

MARK TOWNLEY
SOLAR OBSERVER

Mark is one of the experts behind our big eclipse feature. Find out how observe the event on a budget, make filters and more. *Page 36*

KEATON STONE
TV PRODUCER

Stargazing LIVE's assistant producer gives us the inside scoop on what's in store in the upcoming series. *Page 32*

Welcome

The best solar eclipse for many years arrives this month

On the morning of 20 March, a thin tract of Earth's surface off the northwest coast of the UK will experience a total solar eclipse. While Svalbard and the Faroe Islands are the only landmasses that will experience totality, the whole of the UK is in line for its most significant eclipse event since the total eclipse over Cornwall in August 1999.

We want everyone to experience the incredible sight that will be unfolding on 20 March – and the good news is that there are lots of ways to do so. So whether what you have to hand is a colander, a pair of binoculars, or you want to image the eclipse in white light with your scope, turn to page 36 to find out how.

Stargazing LIVE will also be covering this stunning event on BBC Two this month, in the culmination of its three-night run from Wednesday 18 March to Friday 20 March. Turn to page 32 to find out all about what's in store for the 2015 series, including the live eclipse show on BBC One, and read our exclusive interview with presenter Liz Bonnin on page 44.

Enjoy the issue!

Chris Bramley Editor

PS Next issue will be on sale 19 March.

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The more we know about what you like, the better placed we are to bring you the best magazine possible. So we'd like to invite you to join our online reader panel 'Insiders'.

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Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

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Find out what the *Stargazing LIVE* team will be exploring in this year's series on page 32

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All the details of our latest issue, plus news from the magazine and updates to our website

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The *BBC Sky at Night Magazine* team discuss the latest astro news in our monthly podcast

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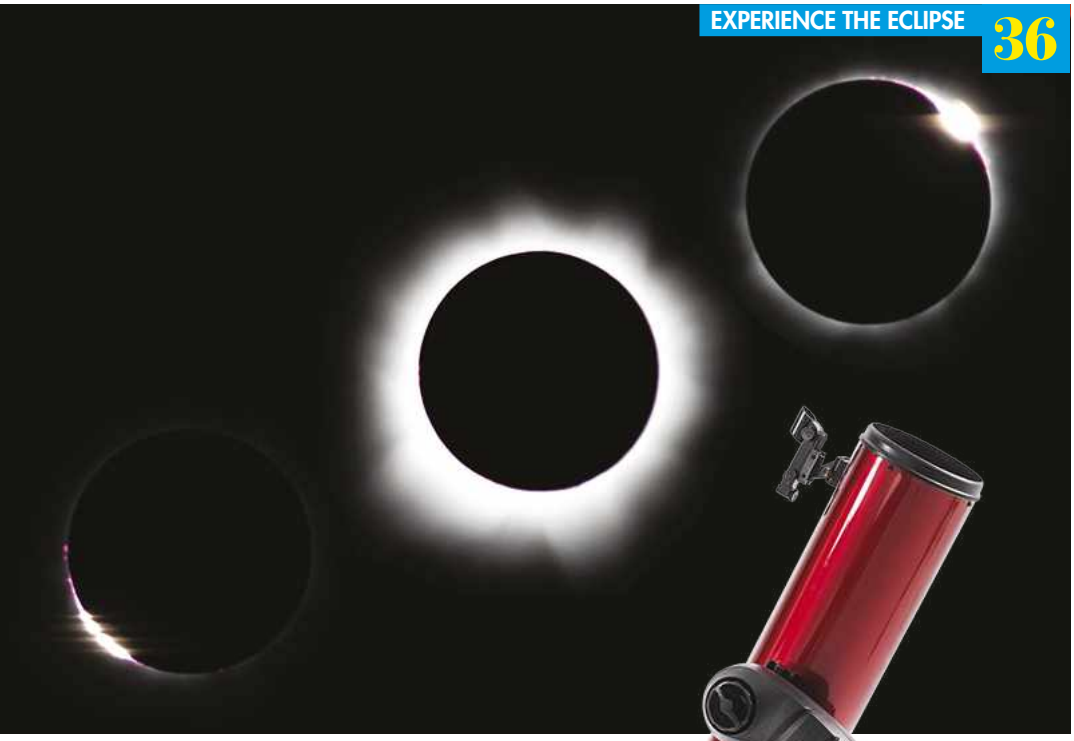
In the magazine

NEW TO ASTRONOMY?
See *The guide* on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary



FEATURES

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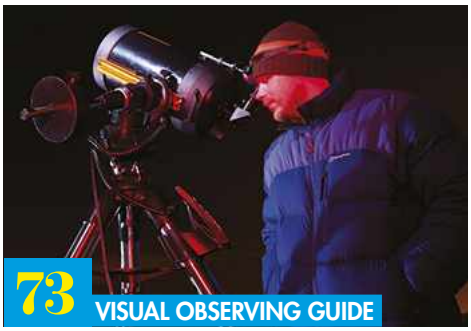

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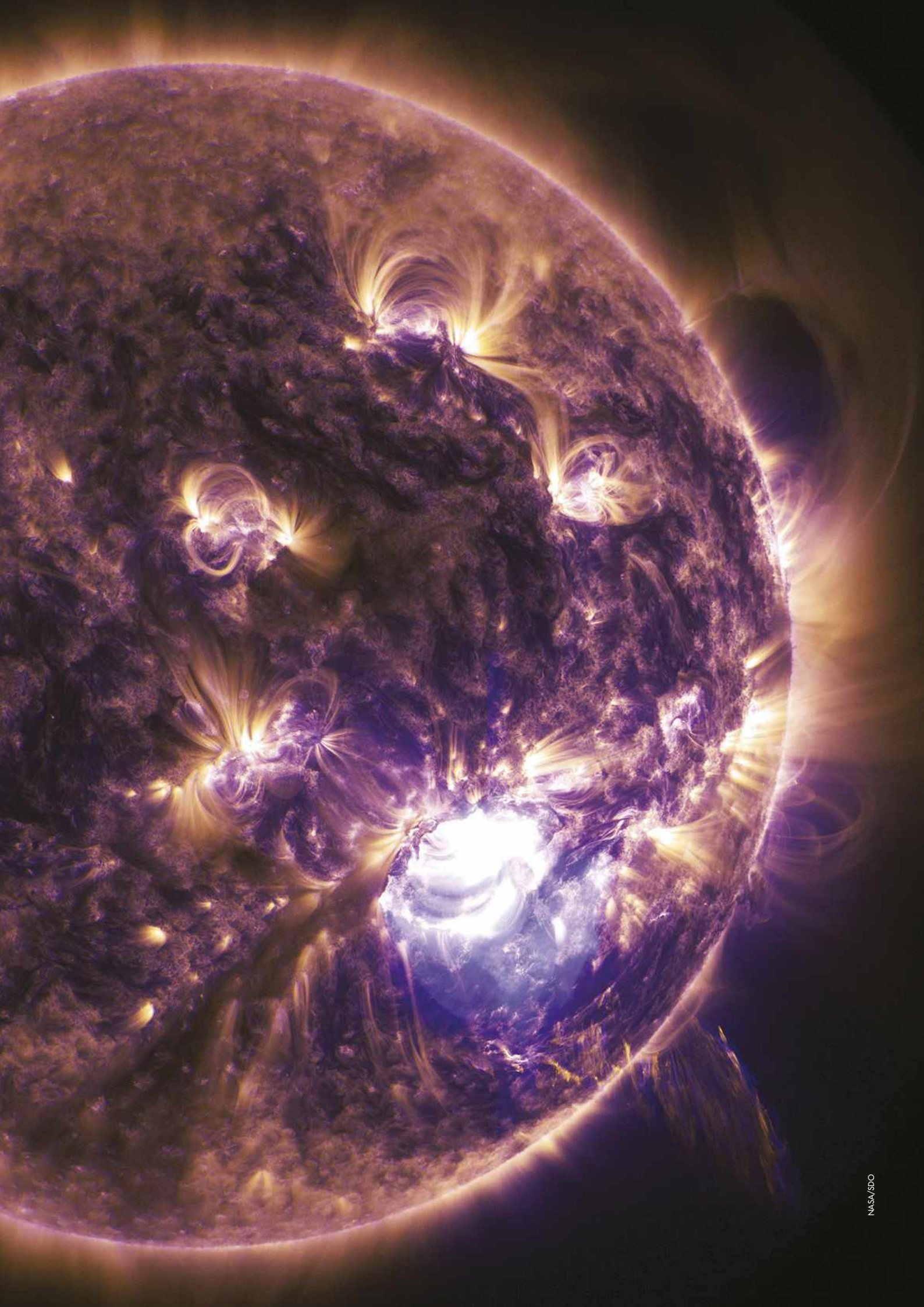
Violent in violet

Solar Dynamics Observatory, 19 December 2014

Our star's fiery nature is captured in all kinds of wavelengths and colours

Every day NASA's Solar Dynamics Observatory beams back breathtaking images in a rainbow of colours, depicting our star in various wavelengths of light. This stunning shot is predominantly at 211 Ångströms, the wavelength emitted by iron-14 isotopes. By viewing light emitted at this wavelength we are able to see magnetically active regions in our star's corona.

Here, a massive solar flare can be seen erupting from the lower right of the Sun. It was designated as an 'X-class' flare, the most powerful type. The Solar Dynamics Observatory is constantly monitoring our star and plays a vital part in warning us when eruptions like this take place, as these powerful radioactive outbursts can sometimes have a negative effect on electrical systems on Earth.



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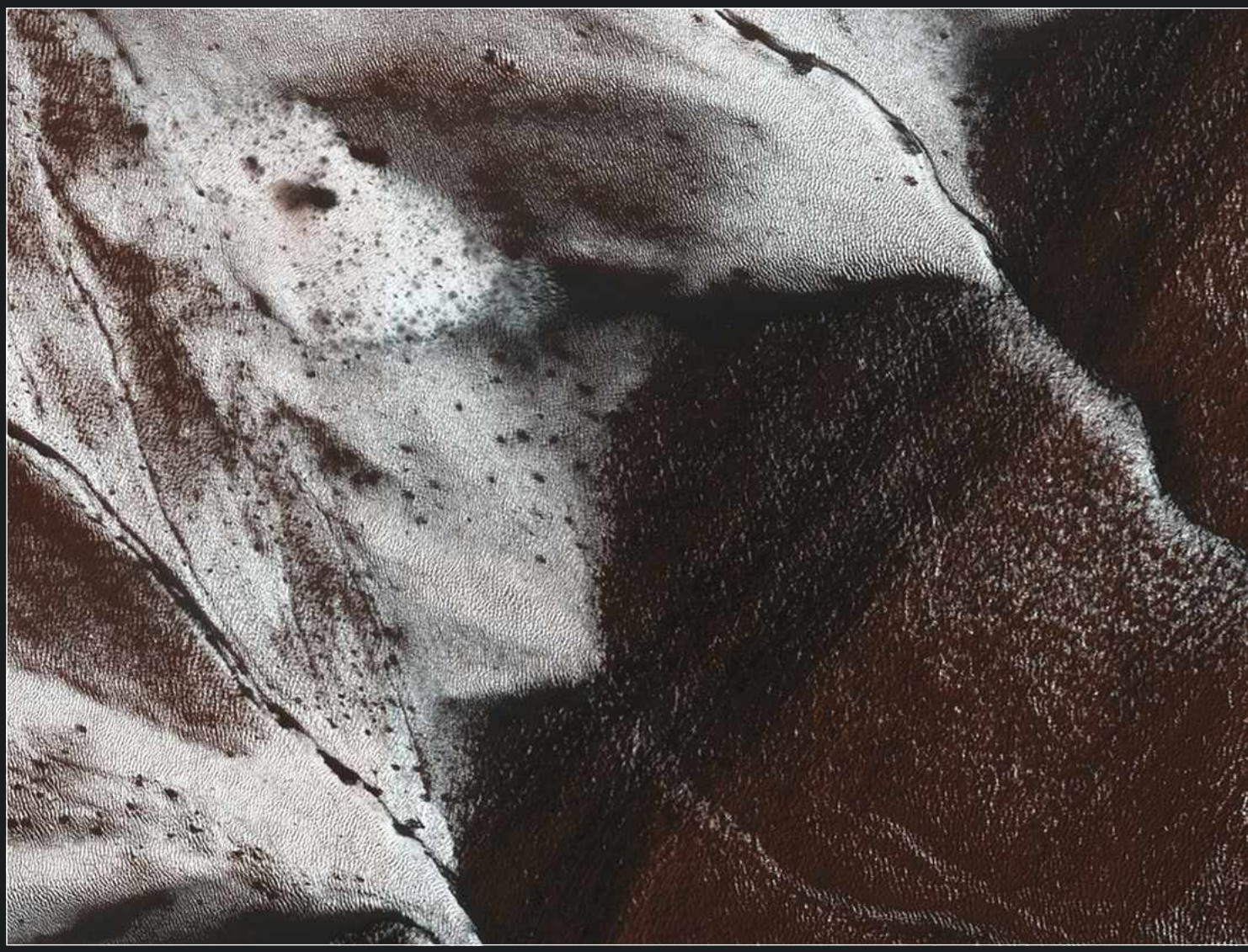


▲ A frosty face

MARS RECONNAISSANCE ORBITER
30 NOVEMBER 2014

The tract of Martian land captured in this image by NASA's Mars Reconnaissance Orbiter is roughly 1.5x3km. The image shows south-facing gullies covered in a layer of frost.

Dark skies ▶

EUROPEAN SOUTHERN OBSERVATORY
7 JANUARY 2015

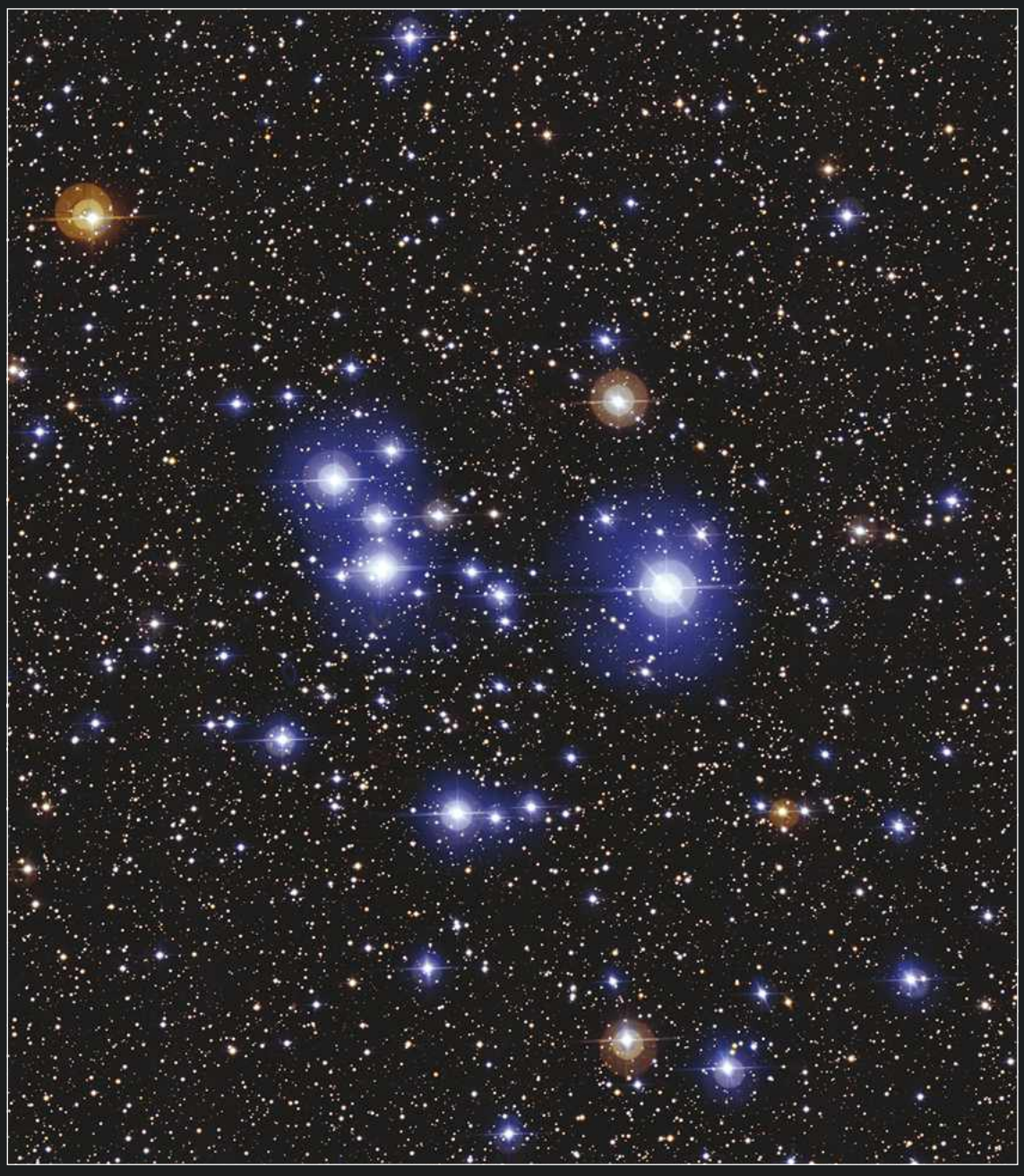
The abundance of gas and dust in dark nebula LDN 483 is so dense it has blocked out the light of the stars behind it. This ominous celestial object is located around 700 lightyears away from Earth in the constellation of Serpens.

NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, ESO X 2, ESA/HUBBLE AND NASA,

◀ Galactic strip light

HUBBLE SPACE TELESCOPE
22 DECEMBER 2014

The 45,000 lightyear long lenticular galaxy IC 335 appears edge-on in this shot from the Hubble Space Telescope. Behind IC 335 are numerous other distant galaxies millions of lightyears apart. IC 335 itself is part of the Fornax Galaxy Cluster.



A juvenile gathering ▶

EUROPEAN SOUTHERN OBSERVATORY
17 DECEMBER 2014

Bright blue stars dominate the frame in this image of open cluster M47 captured by the Wide Field Imager camera on the MPG/ESO 2.2m telescope at ESO's La Silla Observatory. It is the abundance of blue stars that reveal the cluster's youth.

Bulletin

The latest astronomy and space news written by **Hazel Muir**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers

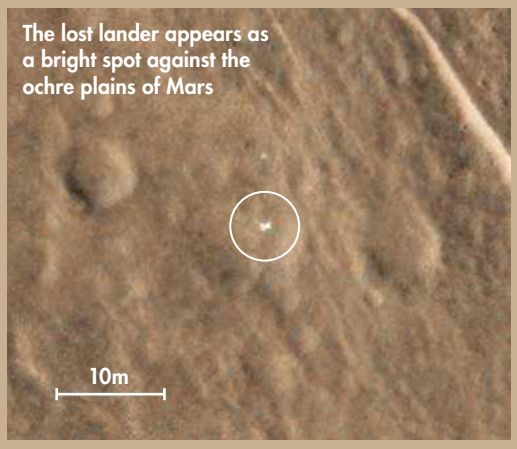
Beagle 2 found on Mars

A NASA spacecraft has spotted the silent probe on the Martian surface

BEAGLE 2 HAS BEEN discovered on Mars after 12 years of radio silence. The UK-led lander mission, which hitched a ride with ESA's Mars Express spacecraft, was dropped down to the Red Planet on 19 December 2003 but failed to communicate after its scheduled touchdown. It had been presumed destroyed, but new images taken by NASA's Mars Reconnaissance Orbiter show Beagle 2 intact on the surface, confirming that the entry, descent and landing sequence all worked as planned. The probe currently lies about 5km from the centre of its expected landing area.

However, the observations hint that only two or at most three of its four solar panels opened. This would explain why no signals were ever received from the lander, because all four panels had to open to expose its radio antenna, allowing it to transmit data and receive commands.

"Not knowing what happened to Beagle 2 remained a nagging worry," says Rudolf Schmidt, who was ESA's Mars Express project manager at the time. "Understanding now that Beagle 2 made it all the way down to the surface is excellent news."



The lost lander appears as a bright spot against the ochre plains of Mars

The enthusiastic leader of the Beagle 2 project, Prof Colin Pillinger of the Open University, died in May 2014. "It was a great pity we couldn't have delivered the world-class science Beagle 2 may have brought, and even sadder that Colin and other colleagues who are no longer with us did not live to see the discovery that Beagle 2 made it to Mars," says mission manager Mark Sims from the University of Leicester.

► See Comment, right

Beagle 2 as it should have been, had all its solar panels unfurled correctly

COMMENT

by Chris Lintott

If the Mars Reconnaissance Orbiter had been at Mars back in 2003, its HiRISE camera might have witnessed Beagle 2 swinging safely beneath its parachute. Instead, I and many others assumed that the landing attempt had ended in a spectacular crash. The Beagle team didn't deserve much of the criticism they got, but the presumed failure of the landing system made it easy to write Beagle off as a bad idea, something to be quietly forgotten about in the corridors of ESA headquarters.

One picture would have made all the difference: with evidence of a successful landing in hand, Colin Pillinger would have stormed the stages of Europe, demanding the immediate dispatch of a whole fleet of Beagles. Beagle 2 was always a risky mission, but if it could reliably land then getting a working mission just becomes a case of rolling the dice more than once. For the want of an image, the history of Mars exploration changed.

CHRIS LINTOTT co-presents *The Sky at Night*

Dawn begins mission at Ceres

The spacecraft will be the first to orbit the vast space rock

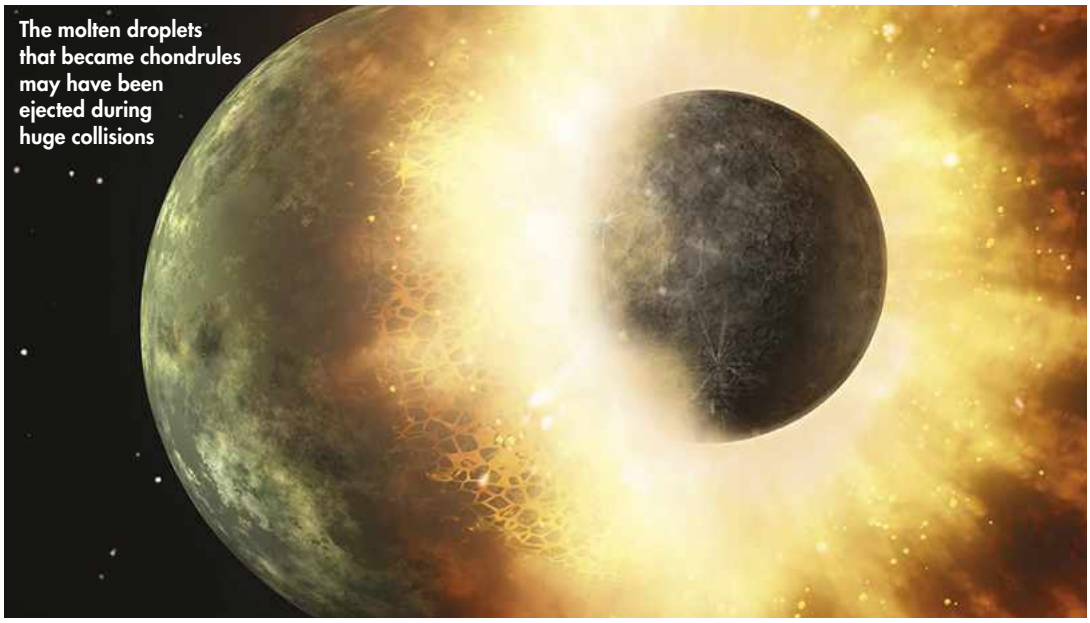
THE DAWN SPACECRAFT will arrive at dwarf planet Ceres on 6 March 2015 then enter into orbit around it in late April. With a diameter of about 950km, Ceres is the largest object in the Asteroid Belt between Mars and Jupiter, and the only dwarf planet in the inner Solar System. It has never been visited by a spacecraft before.

NASA's Dawn launched in 2007 and orbited the smaller asteroid Vesta, which is more than 500km wide, for 14 months during 2011 to 2012. Its mission to Ceres marks the first time a spacecraft has ever orbited two Solar System targets.

"Ceres is almost a complete mystery to us," says Christopher Russell from the University of California, Los Angeles, lead scientist for the mission. "All we can predict with confidence is that we will be surprised."

www.nasa.gov/dawn

▲ **There are a lot of reasons to be excited about Ceres, among them its potential as a reservoir of water-ice**



The molten droplets that became chondrules may have been ejected during huge collisions

A TWIST ON THE ORIGINS OF PLANETS

SPACE ROCKS THAT crashed to Earth have often been seen as relics of the early Solar System, but now astronomers are questioning this. A new study suggests that they might actually be the debris created from planetary formation.

Most meteorites are studded with chondrules, tiny, glassy grains that were once molten droplets. Traditional theories suggest that chondrules collided with dust and gas in the early Solar System to form the seeds of planets. But computer simulations led by Brandon Johnson from the Massachusetts Institute of Technology hint that chondrules came later.

Their results suggest bodies as large as the Moon existed well before chondrules, which were probably created in collisions between Moon-sized planetary embryos that shot out molten plumes, and that the residual droplets from these plumes cooled to form the chondrules.

"Meteorites aren't actually representative of the material that formed planets – they're these smaller fractions of material that are the byproduct of planet formation," says Johnson. "It also tells us the early Solar System was more violent than we expected."

www.mit.edu

NEWS IN BRIEF

SLOAN RELEASES STUNNING OBSERVATIONS

The Sloan Digital Sky Survey released its latest public observations in January 2015, detailing the properties of nearly half a billion stars and galaxies. The survey was made by a telescope in New Mexico that began mapping the cosmos in 1998.

"We've searched nearby stars for planets, probed the history of our Milky Way and measured nine billion years of our Universe's accelerated expansion," says Daniel Eisenstein from the Harvard-Smithsonian Center for Astrophysics in Massachusetts, director of the current project phase.

NEW FORECASTS FOR SOLAR STORMS

Although scientists don't completely understand what triggers solar flares, two physicists have identified features that might help to predict them in future. This could lead to automated warnings of the outbursts, which can cause power failures on Earth and damage orbiting satellites. Monica Bobra and Sebastien Couvidat from Stanford University in California used software that looks for patterns that precede flares, such as magnetic field shapes, then 'learns' from them.

NEWS IN BRIEF

GOLDILOCKS AND THE EIGHT PLANETS

Astronomers have confirmed the discovery of eight new planets in the 'Goldilocks' zones of their stars, orbiting at a distance just right for liquid water to exist on their surfaces. This doubles the known number of small planets less than twice as wide as Earth believed to be potentially habitable.

"Most of these planets have a good chance of being rocky, like Earth," says Guillermo Torres from the Harvard-Smithsonian Center for Astrophysics in Massachusetts. All the planets were originally identified as possible alien worlds by NASA's Kepler spacecraft mission and confirmed during follow-up analysis.

MIGHTY ASTEROID PASSES EARTH

A large asteroid 0.5km wide passed Earth within about three times the Earth-Moon distance on 26 January. Astronomers predict that no known space rock as big as this will come so close to Earth until 2027.

Analysis of the body should provide insights into the Solar System's history. "Asteroids provided Earth with the building blocks of life and much of its water," says Don Yeomans, former manager of NASA's Near-Earth Object Program Office at NASA's Jet Propulsion Laboratory.

Now you see it, now you don't

Neutron star's disappearance confirms theoretical warp in space-time

ASTRONOMERS HAVE MEASURED how a binary star warps space-time and determined the mass of a neutron star in the system. They did so in the nick of time – managing to catch the neutron star with the world's five largest radio telescopes before a wobble in its spin axis made it invisible.

The binary system, known as PSR J1906+0746 (J1906 for short), was discovered in observations by the giant 305m Arecibo radio telescope in 2004. It lies about 25,000 lightyears away.

Astronomers believe J1906 consists of either a white dwarf star and a neutron star, or possibly two neutron stars. Neutron stars are superdense objects typically about 15km wide that form when massive stars run out of fuel and explode, leaving behind a collapsed core.

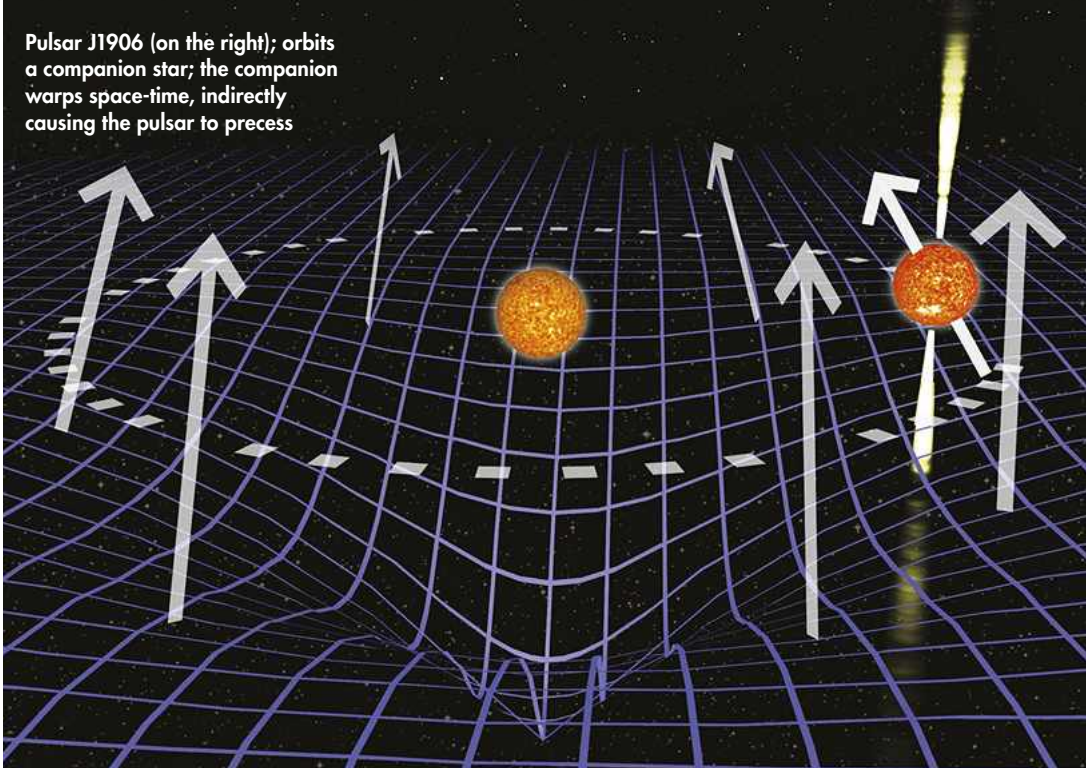
Neutron stars spin rapidly and emit lighthouse-like beams of radio waves from their poles. If these sweep across Earth, astronomers can measure regular radio 'beeps' and the neutron star is classed as a pulsar. The J1906 pulsar spins every 144 milliseconds.

By monitoring the system for several years, a team led by Joeri van Leeuwen from the Netherlands Institute for Radio Astronomy has shown that the pulsar and its companion, which have a close four-hour orbit, are both roughly 1.3 times as massive as the Sun.

"Such mass measurements are required for precisely understanding gravity, the force that is intimately linked to the behaviour of space and time," says van Leeuwen. The observations allowed the team to test general relativity, Albert Einstein's theory of gravity. It suggests a neutron star's spin axis should precess, or 'wobble', as it moves through the gravitational well of a massive companion.

Sure enough, the orientation of the pulsar's axis changes by 2.2° each year. Unfortunately, however, this means it has disappeared from view. "Through the effects of the immense mutual gravitational pull, the spin axis of the pulsar has now wobbled so much that its beams no longer hit Earth," says van Leeuwen.

The pulsar is now invisible to even the largest telescopes on Earth. "This is the first time such a young pulsar has disappeared through precession," van Leeuwen adds. "Fortunately this cosmic spinning top is expected to wobble back into view, but it might take as long as 160 years."
www.naic.edu



Pulsar J1906 (on the right); orbits a companion star; the companion warps space-time, indirectly causing the pulsar to precess

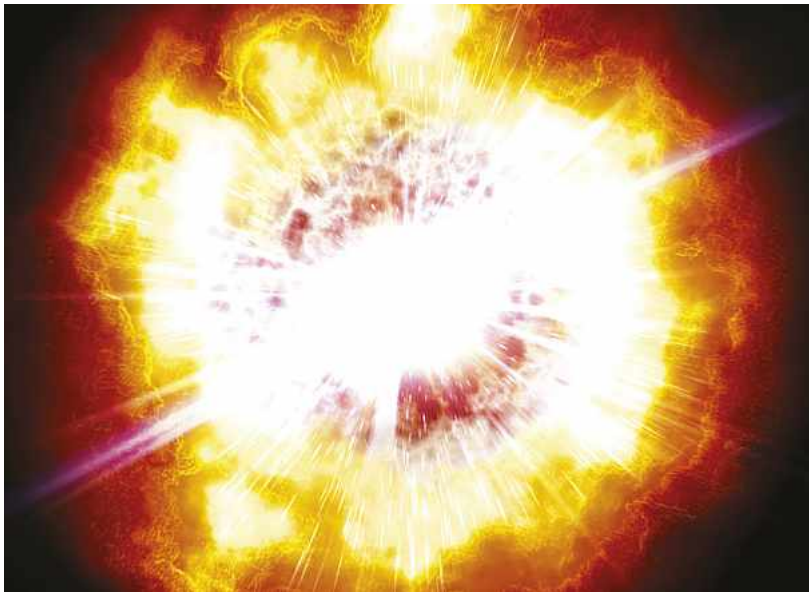
DAVID A. AGUILAR (CFA), JOERI VAN LEEUWEN/ASTRON

CUTTING EDGE

Our experts examine the hottest new research

Space's flickering candles

The yardsticks we use to measure the Universe may not be as reliable as was once thought



Type Ia supernovae may not all shine at the same precise brightness, throwing doubt on their use as standard candles

ISTOCK

Ever since we realised that the Universe was expanding, astronomers have made it their business to provide ever-improving measurements of the speed of that expansion, a quantity known as Hubble's constant. Pinning down its value is a matter of finding a suitable set of 'standard candles', objects with a constant brightness. If you know how bright something should be, and you see how bright it actually appears, you can work out its distance.

For the past two decades, the standard candle of choice has been Type Ia supernovae. These brilliant sudden explosions are believed to be the result of material piling up on the surface of a white dwarf, dragged by gravity from a companion star in a binary system. Once the mass of the accreted material pushes the star across a critical threshold, an explosion is the inevitable result, and because the amount of fuel is the same you can see why Type Ias would always go off with the same sized bang.

Studying Type Ia supernovae revealed for the first time that the Universe's expansion was accelerating, something we now attribute to a mysterious force we call 'dark energy'. But as measurements have become more refined, the story has become more complicated. Type Ia supernovae, it seems, are not precisely standard.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

Various corrections must be applied before they can be used as yardsticks, and at least some Type Ias seem to have a different origin altogether and have to be discarded.

A new paper investigates another potential anomaly. Astronomers noticed a little while ago that there seemed to be a difference between the supernovae that occurred in elliptical and spiral galaxies. Another way of putting this is that the behaviour of the supernova was affected by the mass of the galaxy; most ellipticals are more massive than most spirals so this amounts to the same thing.

Why this should be is somewhat mysterious, but the new paper helps by looking not at whole galaxies, but at the region in which the supernova occurred. Once you do that, it turns out that what's controlling the behaviour of the supernova is star formation; more star formation produces fainter supernovae. Why? I don't know, but it has profound consequences. It's not enough to have a good set of standard candles; you need to calibrate them.

> "It turns out that what's controlling the behaviour of the supernova is star formation"

For supernovae, this means finding examples in galaxies close enough to have individual Cepheid variable stars observed.

Cepheids pulse with a period that depends on their brightness, and so observations of their slow brightening and fading reveal their luminosity. The problem is that they are bright, hot and young stars, and they live where star formation is active. Galaxies in which Cepheids have been observed will have supernovae that are fainter than the average, and that has been dragging down our estimate of the Universe's expansion speed by about three per cent.

It doesn't sound that important, but it amounts to a difference of 440 million years in the age of the Universe. Significant enough to care about and to make me worry about the fact that we simply don't understand why this new dependence on star formation should exist.

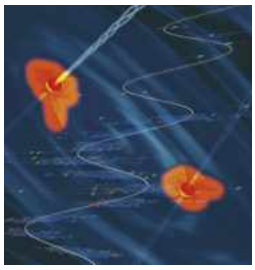
CHRIS LINTOTT was reading… *Confirmation of a star formation bias in Type Ia supernova distances and its effect on measurement of the Hubble constant* by M Rigault et al

Read it online at http://arxiv.org/abs/1412.6501

NEWS IN BRIEF

BLACK HOLES SOON TO MERGE

An unusual repeating light signal from a quasar – an energetic galaxy – hints that it harbours two supermassive black holes in the final phase of merging. PG 1302-102 emits a strong optical signal that rises and falls regularly over about five years. Astronomers think this comes from two giant black holes in a record-breaking close orbit, and that they're doomed to collide. "The black holes in PG 1302-102 are, at most, a few hundredths of a lightyear apart, and could merge in about a million years or less," says Daniel Stern from NASA's Jet Propulsion Laboratory in California.



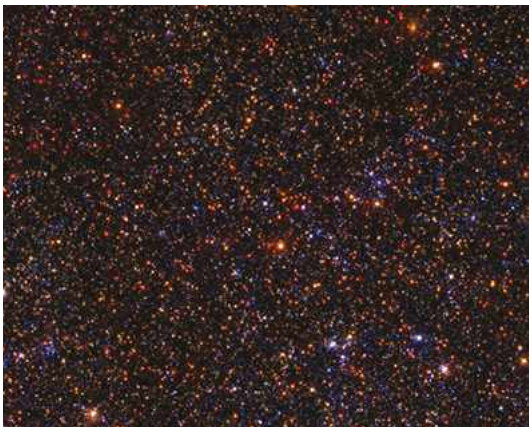
NEW EXOPLANET HUNTER IN BUSINESS

The Next-Generation Transit Survey at the Paranal Observatory in Chile has achieved first light. This array of 12 telescopes will hunt for small exoplanets by looking for the telltale dimming that occurs when a planet passes in front of its host star.

SANTIAGO LOMBEYDA/CENTER FOR DATA-DRIVEN DISCOVERY/CALTECH, ESO/G. LAMBERT, BEN WILLIAMS/JULIANNE DALCANTON/AND THE PHAT COLLABORATION, NASA/CXC/STANFORD/I. ZHURAVLEVA ET AL, ISTOCK

Andromeda's violent past

Many galactic collisions shaped the giant spiral's future



▲ One of the Hubble images of M31; stars of different ages can be distinguished by their colour

THE MAGNIFICENT ANDROMEDA spiral galaxy, M31, had a surprisingly violent history of mergers with smaller galaxies, according to a new study. It suggests M31's history was more chaotic than that of the Milky Way.

Puragra Guhathakurta and Claire Dorman from the University of California, Santa Cruz, studied the motions of stars in M31 using data from the Keck Telescopes in Hawaii and the Hubble Space Telescope. "The high resolution of the Hubble images allows us to separate stars from one another in the crowded disc of Andromeda," says Dorman. Young and old populations of stars showed very different motions, implying that a well-ordered star disc was disturbed regularly by collisions with small galaxies.

www.hubblesite.org

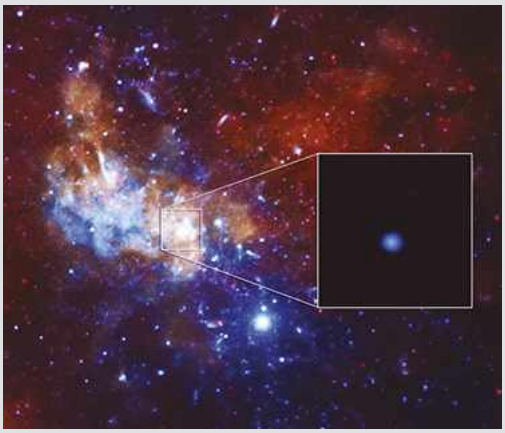
OUR BLACK HOLE'S DRAMATIC FLARE

THE BRIGHTEST X-RAY flare ever detected from the supermassive black hole at the heart of the Milky Way has been observed by NASA's Chandra space telescope. The huge explosion was seen in September 2014 and follows on from disappointment last year when a gas cloud named G2 failed to produce its own megaflares.

"G2 didn't produce the fireworks we were hoping for," says Daryl Haggard from Amherst College in Massachusetts. "However, nature often surprises us and we saw something else that was really exciting."

This X-ray flare was three times brighter than the previous record holder, and probably unrelated to G2.

www.nasa.gov/chandra



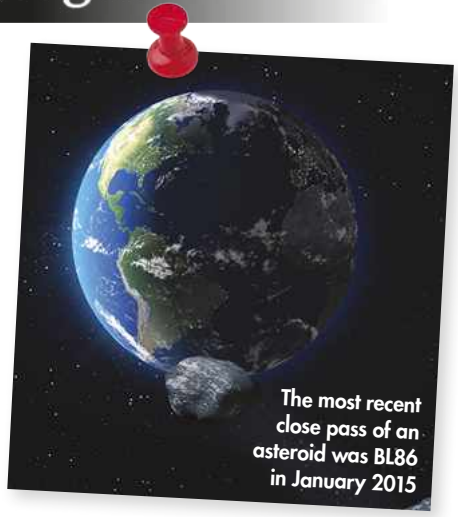
The X-ray flare was colossal: 400 times brighter than those usually issued by our supermassive black hole

Looking back The Sky at Night

March 1992

On 15 March 1992, a broadcast of *The Sky at Night* entitled 'Vermin of the Skies' discussed asteroids in Solar System. A vast number orbit in the Asteroid Belt between Mars and Jupiter and pose no threat to Earth, but many others regularly pass within Earth's orbit. Some of these can get very close to our planet; famously, a giant asteroid impact is thought to have brought about the extinction of the dinosaurs around 65 million years ago by catastrophically altering our planet's environment.

The vermin of the skies have caused havoc in recent times too; in 1908, the explosion caused by an asteroid (or comet) impact felled trees across 2,000km² of Siberia. Space agencies keep track of known menacing asteroids, but if a big one comes our way, we don't yet have the technology to stop it.



The most recent close pass of an asteroid was BL86 in January 2015

CUTTING EDGE

Our experts examine the hottest new research

The warm heart of Enceladus

New simulations may help to explain the mystery of the subsurface sea on Saturn's tiger-striped moon

NASA/JPL/SPACE SCIENCE INSTITUTE

▲ **Cassini witnessed the plumes erupting through cracks near Enceladus's south polar region**

One of the most surprising discoveries made by the Cassini spacecraft, still looping through the Saturn system, relates to the small moon Enceladus. Contrary to all expectations, Enceladus was found to be astonishingly active, jetting great geysers of water into space through a set of parallel 'tiger stripe' cracks near its south pole. When Cassini plunged through the plumes to analyse their composition, it detected small amounts of ammonia antifreeze and salt within the water-ice crystals.

The conclusion is that beneath its frozen surface, Enceladus harbours a large volume of saline liquid water, a subsurface sea. This in itself is challenging to explain. Enceladus is tiny and any residual heat from its formation should long since have dissipated – it really ought to be frozen solid. Yet the latest estimates of the rate of energy release from the south polar region is about 10 gigawatts, roughly equivalent to five nuclear power stations. So the mysteries about Enceladus are: what processes are responsible for providing all this energy; and have they been sustained throughout its history or have we just happened to observe the moon during a particularly active phase?

LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

Possible energy sources in Enceladus's core include heating from the decay of radioactive isotopes of aluminium and iron (as is partly responsible for the hot interior of Earth), or heat released from exothermic chemical reactions such as when iron-rich minerals react with seawater (which drives certain hydrothermal vents on our planet's seafloor). But even with these, Enceladus would still have frozen solid within a billion years or so. An additional source of heating must be present.

To explore these, American astronomers Bryan Travis and Gerald Schubert built a computer model of Enceladus. The most probable energy source, theorists believe, is tidal heating: the icy shell atop the liquid ocean is continually being deformed and flexed by Saturn's gravity and so generates heat through friction. But Travis and Schubert's model suggests that the ocean within Enceladus is still not sustainable with the degree of steady tidal heating that the moon is currently experiencing.

> "Any residual heat should have long since dissipated – Enceladus ought to be frozen solid"

To keep the interior warm enough to be liquid, they calculate that Enceladus must also undergo additional short-lived bouts of intense tidal heating, and that these must occur at least every 100 million years to prevent it from totally solidifying. It is plausible that nudges from the gravity of Saturn's other moons could cause shifts in the eccentricity of its orbit and could therefore drive these kinds of variations in tidal heating.

Another important factor, Travis and Schubert argue, is that the pattern of heat circulation in the interior of Enceladus causes sinking flow around the equator and upwelling at the poles, which helps to focus the available heat at the tiger stripes. Also, much of the water squirted out of the tiger stripe cracks falls back down again, smothering Enceladus in a very fluffy, porous layer of snow that serves to insulate the moon and so helps to keep surface warmer than it would otherwise be.

LEWIS DARTNELL was reading… *Keeping Enceladus warm* by B J Travis and G Schubert
Read it online at http://www.sciencedirect.com/science/article/pii/S0019103514006459

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What's on

Our pick of the best events from around the UK

SPA 2015 Convention

The Institute of Astronomy, Cambridge, 28 March 2015, 10am

PICK OF THE MONTH

▲ **Clockwise from top: astronaut Tim Peake; comet 67P; ExoMars concept; and our star**

The annual Society for Popular Astronomy (SPA) convention returns and, following on from ESA's success with Rosetta at comet 67P/Churyumov-Gerasimenko and confirmation of UK astronaut Tim Peake's mission to the ISS, the theme for this year is – quite naturally – Europe in space.

The event will include lectures from Dr Helen Walker from the Rutherford Appleton Laboratory on commanding a UK satellite, solar scientist Dr Lucie Green on European endeavours to observe our star, the Open University's Prof Monica Grady on ESA's ExoMars mission and Prof Tim O'Brien from the University of Manchester on Solar System exploration.

The event is free to all, but entry to this year's Sir Patrick Moore Lecture on Rosetta, given by Prof Ian Wright from the Open University, is ticketed.

www.popastro.com

BEHIND THE SCENES

THE SKY AT NIGHT RETURNS IN APRIL

***Sky at Night* presenters Chris, Maggie and Pete will be on *Stargazing LIVE* this month**

STARGAZING LIVE

With *Stargazing LIVE* coming to BBC Two for three nights on 18, 19 and 20 March, *The Sky at Night* will be taking a break from our screens this month, for one month only. The programme will be back in April to bring you monthly coverage of the top stories from the forefront of space science and engineering.

Keep up with team at bbc.co.uk/skyatnight or via Twitter @BBCStargazing

Images of the Universe

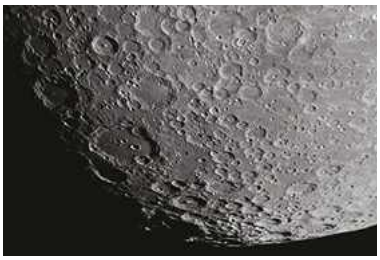
Tiverton & Mid Devon Astronomical Society, Tiverton, 6 March 2015, 7.30pm

BBC Sky at Night Magazine reviews editor Paul Money journeys to Tiverton & Mid Devon Astronomical Society to explain how he was inspired to become an astronomer himself using 10 astronomical images. The event is free to all.

www.tivas.org.uk

Mascons, Maria, Mega-Impacts and Moon Rocks

The Astronomical Society of Glasgow, Strathclyde University, Glasgow, 19 March 2015, 7.30pm



Discover more about the geology of Earth's constant companion with Dr Simon Cuthbert, lecturer in Earth Sciences at the University of West of Scotland. There is no entry fee but the society recommends booking in advance.

www.theasg.org.uk

Observing Evening

Hertford Astronomy Group, Welwyn Garden City Golf Club, Welwyn Garden City, 11 March 2015, 8pm

Let the members of the Hertford Astronomy Group guide you through March's night sky delights, which include the Hyades, the Pleiades, the Orion Nebula and Jupiter. Telescopes will be provided. Entry is free to members and under 17s, £3.50 to non-members.

www.hertsastro.org.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

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A PASSION FOR SPACE

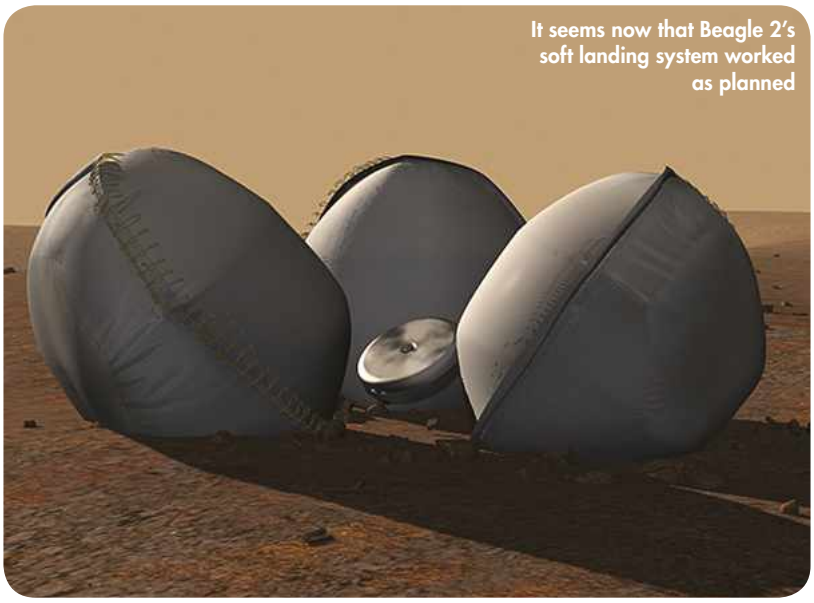
with **Maggie Aderin-Pocock**

The Sky at Night presenter reflects on the revelation that Beagle 2 landed safely on Mars after all

I used to joke that one day I would like to retire to Mars and find out what became of Beagle 2; because of its high profile, the British probe's silence became one of the enigmas of modern space science, until now. But after 11 years in the dark, light has finally being shed on the fate of the lander.

Launched on 2 June 2003 aboard Mars Express, the Beagle 2 lander was small and very compact. Initial lander concepts for the Mars Express mission were rejected due to lack of funding, but instead an exobiology mission was put forward to look for signs life on Mars. Beagle 2 was the lander designed to carry this out, created by a consortium of British academics led by the late Prof Colin Pillinger, working to the stringent budget, mass and volume requirements required by the project.

All seemed to go well when the lander was released from Mars Express, but when touchdown was due on 25 December 2003, the hoped for signal never came. Over the following months repeated attempts were made to contact Beagle 2, including with the 76m Lovell radio dish at Jodrell Bank, but by February 2004 the lander was considered missing. Some thought that the complex landing system may have failed, causing the probe to crash, but the enquiry set up to work out what went wrong concluded that "...no definitive cause of the failure can be identified due to lack of data – radio, telemetry or visual."



It seems now that Beagle 2's soft landing system worked as planned

New data, new knowledge

Fast forward to January 2015 and the release of a series of pictures taken by NASA's Mars Reconnaissance Orbiter over a number of months. These images show a group of objects on the surface of Mars that look as if they could be components of the Beagle 2 lander, and rather than smashed debris the remains look to be intact. Early analysis indicates that the lander is on the surface with two of its four solar panels undeployed, thus trapping the communications antenna and rendering the probe silent.

So what can we conclude from this news; should we be happy or sad at the discovery? Although Beagle 2 has been seen as a failure by some, this now appears not to be the whole story. Missions to Mars have always been challenging and to date they have a failure rate of around 50 per cent. So this successful touch down on the surface should be celebrated as verification of the mechanisms that slowed the spacecraft down to a soft landing. What's more, the lander has seeded technology to other missions such as Exomars, the ESA probe that will autonomously search for life on Mars after it is launched around 2018.

Team members who worked on the Beagle 2 project have expresses mixed feelings: joy at finally finding out what happened to the probe; regret that the mission got so close to success; and sadness that Prof Colin Pillinger, who died last year and was the powerhouse behind the project, never found out the whereabouts of his brainchild.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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JON CULSHAW'S EXOPLANET EXCURSIONS

What could be better than an eclipse? An eclipse with added volcanoes, obviously

Having witnessed two glorious exostellar eclipses in recent excursions, perhaps we ought to complete the trilogy in honour of the hugely anticipated total solar eclipse that's set to occur over the Faroe Islands on 20 March.

There's one other variety of eclipse I'm curious to see. Usually eclipses have the 'black hole' effect, but what if the eclipse-causing object was a fiercely volcanic world akin to Jupiter's moon Io? I'll take a look around the system of Mu Arae in the constellation of Ara, the Altar: hopefully here we should locate such a spectacle.

Mu Arae lies at a distance of 50.6 lightyears from Earth. It isn't visible from UK skies, but at mag. +5.1 it's just about visible to the naked eye from the southern hemisphere. There are four planets believed to be orbiting this star, and one of them – Mu Arae b, in the star's habitable zone – provides exactly what we're looking for: an innermost moon with a larger neighbouring moon close by.

This is a configuration very similar to Jupiter's Io. Upon a closer inspection, the gravitational effects on this moon of its passage between planet Mu Arae b and its neighbouring body do indeed cause unending friction and violent volcanic activity. This poor world is squeezed and disrupted on its orbit like an eternally tormented stress ball.

Observing this world gives a sense of indigestion. I steer the Cruiser Globe to the correct position for this moon to eclipse parent star Mu Arae. At confirmation of 'first contact' this eclipse begins just like those seen from Earth, with a steadily advancing 'bite'. As the event progresses, the blackened area appears through my eclipse viewer to be gaining a red hue in places. There is no distinct pattern to this just at the moment, it's more like a deep red 'lens flare' bathing the black void.

Moments before the totality of Mu Arae, the red hue deepens in intensity, and as the stellar corona flashes into view in just the same way as that of our own Sun does, there's a second totality effect which looms forth like a mood lamp with its dimmer gently turned up.

This is a breathtaking exoeclipse to witness, with the wonderful extra dimension of volcanic activity made visible. The light of the totally eclipsed star allows the volcanic activity to shine with the colour of a piece of ironwork beginning to glow red hot in the blacksmith's forge. Pockets and filaments of glowing redness like squashed, backlit raspberries are scattered across the black disc, resembling a growth of lichen on a stone gatepost.

This vision generates a sound in the imagination like the electrical hum heard beneath a pylon. Meanwhile around the edges, volcanic fountains sear upwards, cousins of the ice fountains of Enceladus, visible next to stellar prominences dotted around the black disc at the two, four, five, seven and 11 o'clock positions. It's a vision of serene violence against the backdrop of a piercing silvery corona.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION BY MARK GARLICK. PHOTO: EMMA SAMMS

BBC

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This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's. Heather Couper and Nigel Henbest's *Stargazing 2015* is a month-by-month guide to the year and you'll be able to find all the best sights with Patrick Moore's *The Night Sky. Stargazing with Binoculars* by Robin Scagell and David Frydman contains equipment and observing guides, and you'll be viewing planets, galaxies and more with Storm Dunlop's *Practical Astronomy.*

PHILIP'S

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: Do you feel better knowing that Beagle 2 landed on Mars (fairly) intact

@JP_Astronomy I feel relieved. Professor Pillinger would have been proud knowing his creation is there safe.

Sheena Rogers Can we name that little piece of Mars after Colin now? How fitting that would be.

Darren Hill It's a sad reminder of the razor fine difference between total success and heartbreaking almost...

MESSAGE OF THE MONTH

Battle in the Ardennes

You may be interested in these photos that show me out observing on a cold night in early January at Moulin du Ruy in the Belgian Ardennes. It was the first outing for my Celestron Skyris 132C camera with my 9.25-inch Schmidt-Cassegrain. Although the sky was clear the conditions were far from ideal: Jupiter was low, there was a full Moon and thin high-level cloud – mainly from that other modern-day blight alongside light pollution, aircraft contrails – and the temperature was –5°C, as evidenced by the frost on everything. Nevertheless, I am pleased with the result. More practise with the hardware and processing software will hopefully lead to greater things! Oh yes, and a small observatory would also come in handy...

Clive Murgatroyd, London

Clive, your dedication is an example to us all. Nice detail on Jupiter too! ***– Ed***

My best investment

Inspired by your *How to* on building a garden observatory (September-December 2009) I built this hybrid version using a commercially available 2.7m fibreglass dome. It was a challenging project but well worth the effort. I love that I can just go out into the garden and spend a spare half hour taking photos, rather than an hour setting up and breaking down again because the clouds roll in. For me, it is the best value investment I have made in my hobby and makes it possible to take shots like this one of M42 in just 95 minutes! Thanks for the excellent articles. Great to see the subject covered again with more details in the free supplement with January's issue.

Kevin Hill, Hertfordshire

A finely detailed image of the Orion Nebula there, Kevin, matched by equally fine construction detail on your garden observatory. ***– Ed***

Taking on Hubble

Each month the incredible pictures in *Hotshots* inspire me to go outside and attempt to capture my own. However, it is easy to get disheartened when comparing one's own efforts with those of experienced amateurs, professionals and Hubble!

I started digital astro imaging a year ago using a modest setup – an entry-level DSLR and a 5-inch Maksutov-Cassegrain. I've been frustrated with most of my results, but as I've learned the best approaches by reading guides, optimising settings and practising, and I've gradually improved. I now recognise the importance of good tracking, good seeing and good image processing. Learning any new skill is a challenge, but just a couple of nights observing and imaging a month can yield great rewards. To anybody out there struggling – it's not easy but it is worth it and you're definitely not alone!

Anthony Fogg, Billingshurst, West Sussex

Your shots are impressive, Anthony, especially the one that shows detail on the ISS. ***– Ed***

OOPS!

In January's feature 'Eclipse: dance of the planets' (page 40) we said that there are 41 active saros cycles. This referred to lunar saros cycles rather than solar ones, of which there are 40, the last starting in July 2011. We also said that each saros series progresses from a partial eclipse to a total eclipse. This is not always the case: some series include a central eclipse between partial and total stages.

Hotshots

This month's pick of your very best astrophotos

PHOTO OF THE MONTH

▲ Winter constellations

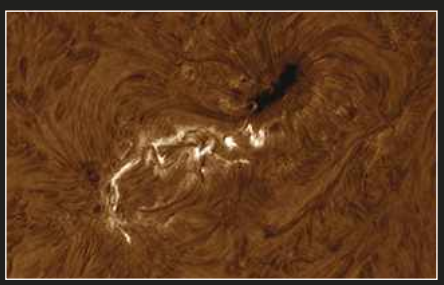
AMIRREZA KAMKAR, KASHAN, IRAN, DECEMBER 2014

Amirreza says: "I like this image because it shows a range of colours in the sky: the red giant star Betelgeuse, green airglow and the blue stars of the Pleiades. As it is a panorama image you can also see some deep-sky objects, including M35, M36, M37, M38 and M42."

Equipment: Canon EOS 5D MkII DSLR camera, Samyang 24mm lens.

***BBC Sky at Night Magazine* says:** "What a beautiful image. The quiet stillness of the foreground contrasts strikingly with the busy display of stars above. So often airglow can overpower an image, but here Amirreza has judged it just right, adding a hint of contrast to the crumbling yellow structure in the foreground."

About Amirreza: "I lived in a small city for 17 years and could almost see a starry night sky from my back garden. Then one of my friends brought a small telescope into school, which we used to look at the Moon. Soon after I was bought a telescope myself and after seeing Saturn through it I fell completely in love with astronomy."



▲ Solar flare

PETER J WILLIAMSON, SHROPSHIRE
3 DECEMBER 2014

Peter says: "This image of an M-class flare was taken at the Whittington Observatory. It originated in active region AR2222."

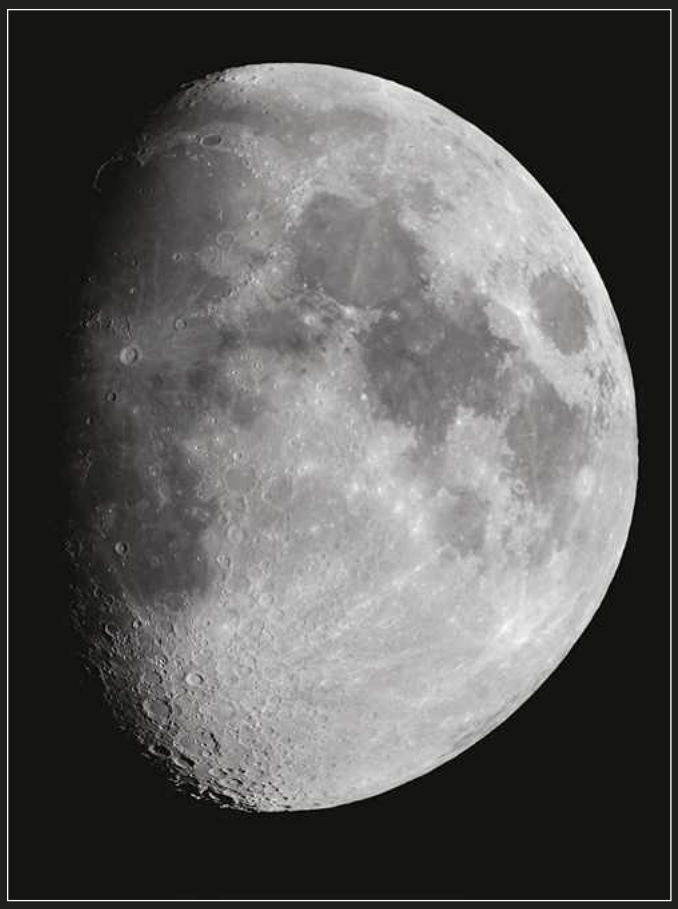
Equipment: ZWO ASI120MM CCD camera, Coronado 3.5-inch SolarMax II solar telescope.

The Helix Nebula ◀

DAVID TROTTER, AUSTRALIA, 12 NOVEMBER 2014

David says: "At just 300 lightyears away, this planetary nebula is pretty close to Earth. On a good night you can look right through the nebula's centre and image galaxies on the other side through a trillion-kilometre-long tunnel!"

Equipment: STL-6303e CCD camera, GSO RC8 telescope, AP900 mount.



The Moon ▶

JON WATSON, EDINBURGH, 2 NOVEMBER 2014

Jon says: "This shot was taken five hours before perigee. The image is a multi-tile composite created from nine HD videos stacked in RegiStax. The mosaic was put together in Canon PhotoStitch and processed in Photoshop, which brought back memories of attempting to glue together a glass I'd broken as a child! This is my first attempt at a Moon mosaic, having only taken up astronomy earlier this year."

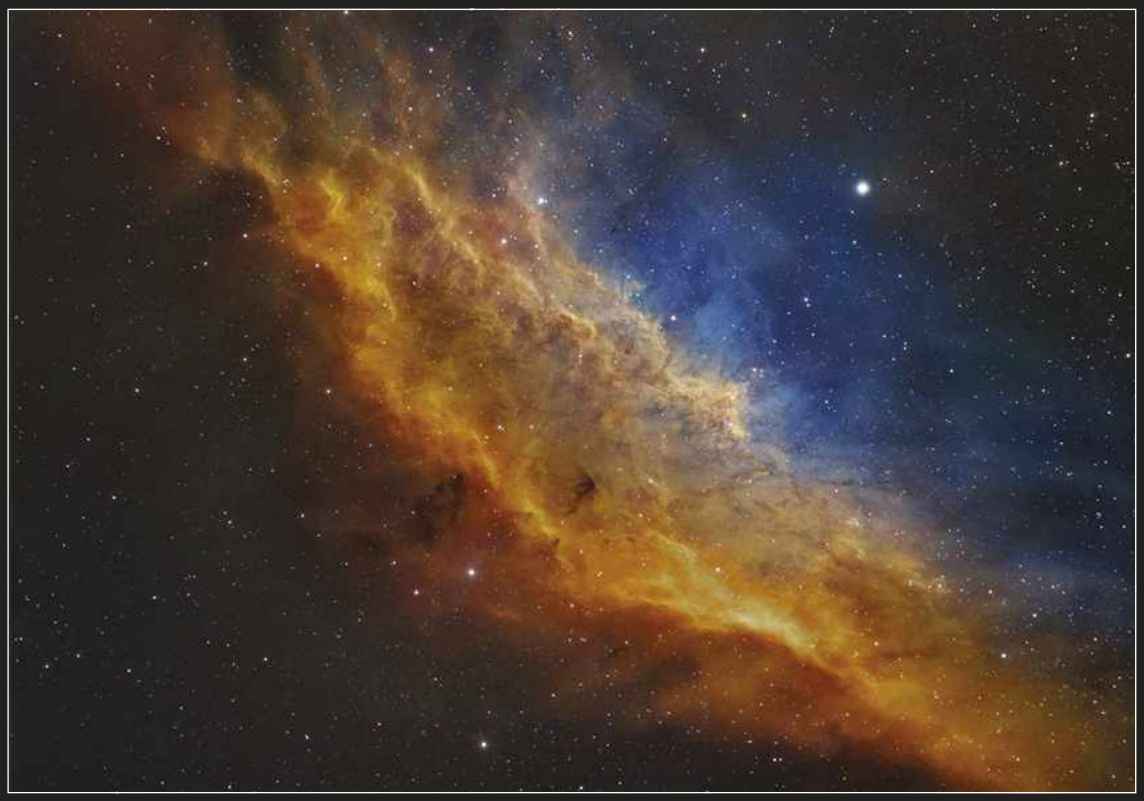
Equipment: HTC One smartphone, 3.5-inch Maksutov telescope.

Star trails ◀

MOHAMMED AISSA MOUSSA GHARDAÏA, ALGERIA 28 NOVEMBER 2014

Mohammed says: "I wanted to capture the night sky above the sand dunes that are prolific in this part of southern Algeria. I was lucky that the Moon was bright enough to illuminate the desert."

Equipment: Canon EOS 5D Mk II DSLR camera, 15mm fish-eye lens.



◀ The California Nebula

KFIR SIMON
GAN YAVNE, ISRAEL
OCTOBER 2014

Kfir says: "I used some older data taken with a 10-inch Newtonian to enhance the central part of the nebula."

Equipment: SBIG ST-8300M CCD camera, William Optics GT-81 triplet refractor, ASA DDM60 mount.

▲ M81

STEPHEN DEAN, ISLE OF WIGHT, 19 DECEMBER 2014

Stephen says: "This is my first attempt at photographing a galaxy with a CCD camera and I'm quite pleased with the result. It is made up of about 4.5 hours of sub-exposures."

Equipment: SBIG ST-2000XM CCD camera, Sky-Watcher 3-inch ED Pro telescope, NEQ6 mount.

▼ The Heart Nebula

CHRIS GRIMMER, NORFOLK, 13 DECEMBER 2014

Chris says: "The Heart Nebula lies some 7,500 lightyears away from Earth in the constellation of Cassiopeia. This is an emission nebula showing glowing gas and darker dust lanes."

Equipment: SXVR-H694 CCD camera, William Optics GT-81 triplet refractor, iOptron CEM60 mount.

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Stargazing LIVE 2015

Series five brings a TV first: the live broadcast of a total solar eclipse

Once again it's time for one of the onscreen celestial highlights of the year, *Stargazing LIVE*... series five! This year, in addition to the usual trio of nightly shows and their *Back to Earth* counterparts there will be an extra morning episode broadcasting this month's total solar eclipse live into living rooms across the country. As well as the high-altitude coverage from the Faroe Islands, Prof Brian Cox, Dara Ó Briain, Liz Bonnin and Dr Lucie Green will be on hand over the three nights of 2015's astronomical extravaganza to discuss everything in the Universe from Jodrell Bank Observatory.

ABOUT THE WRITER

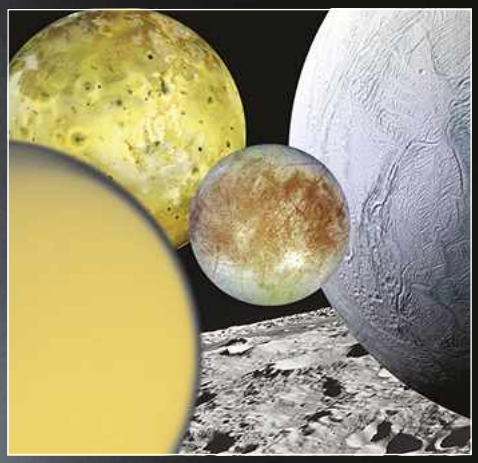
Keaton Stone is a space enthusiast, and assistant producer for *Stargazing LIVE* and other BBC science shows. Follow him on Twitter: @Keaton_S

BBC X 3, ISTOCK X 5, NASA/JPL X 3, ESA AND NASA, JON HICKS, LIZ BONNIN

STARGAZING **LIVE** 2015 – EPISODE GUIDE

EPISODE 1

Stargazing LIVE, BBC Two, 18 March, 8pm
Back to Earth, 9pm



To kick off the series a space superstar joins the team to investigate moons, where they come from, how to observe them and many of their fabulous and curious properties. Plus Brian gets a crash course in Moon landings and there's the chance for viewers to discover new supernovae.

EPISODE 2

Stargazing LIVE, BBC Two, 19 March, 8pm
Back to Earth, BBC Two, 10pm

The celestial ballet of our clockwork Universe is explored, the predictability of planetary orbits and alignments explained, plus a history of the mapping and discovery of the planets. Liz gets a first-hand taste of the effects the eclipse has on Earth and the Rosetta mission is celebrated.

EPISODE 3

Eclipse Live 2015
BBC One, 20 March, 9am

A TV FIRST FROM THE BBC

The team will be joined by guest presenters around the country for this special programme covering the solar eclipse live. Liz will take to the skies above the Faroes for the best chance of seeing totality, plus we'll see how the eclipse affects the weather and tell you where to go next if you've caught the eclipse bug.

EPISODE 4

Stargazing LIVE, BBC Two, 20 January, 9pm
Back to Earth, BBC Two, 10pm

The results and pictures from the day's eclipse spectacle, news on the latest generation of missions to the Sun, plus the results of the citizen science search for supernovae – with the chance for one viewer's discovery to revise the known age of the Universe.

Check www.bbc.co.uk/stargazing for any updates to the order of shows

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STARGAZING LIVE EVENT LISTINGS
Find astronomical societies and observatories hosting their own *Stargazing LIVE* and solar eclipse events near you.

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EXPERIENCE THE ECLIPSE
Learn all about the different ways you can view the eclipse from our team of experts – from projection to detailed hydrogen-alpha views.

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LIZ BONNIN INTERVIEW
Stargazing LIVE's roving reporter shares tales from her time on the show and explains why she thinks it is so important to share science.

Stargazing LIVE in the UK

All around the UK astronomical societies and observatories are running their own events to celebrate *Stargazing LIVE* and watch the eclipse

1. TECHNIQUEST GLYNDWR
Glyndwr University Campus, Mold Road, Wrexham, LL11 2AW
14 March at 6.30pm
www.tqg.org.uk

2. BASINGSTOKE DISCOVERY CENTRE
Festival Place Shopping Centre, Basingstoke, RG21 7LS
18 March at 6pm
www.festivalplace.co.uk/store_profile-4686.htm

3. IRISH ASTRONOMICAL ASSOCIATION
Physics Building, Queen's University, Belfast, BT7 1NN
18 March at 7.30pm
www.irishastro.org.uk

4. KEILDER OBSERVATORY
Keilder Water and Forest Park, Northumberland
18 March at 8pm
www.kielderobservatory.org

5. NORMAN LOCKYER OBSERVATORY
Salcombe Hill Road, Sidmouth, Devon, EX10 0NY
19 March at 7.30pm
www.normanlockyer.com

6. THE OBSERVATORY SCIENCE CENTRE
Herstmonceux Castle and Science Centre, Herstmonceux, East Sussex, BN27 1RN
20 March at 7.30am
www.the-observatory.org

7. MEXBOROUGH AND SWINTON ASTRONOMICAL SOCIETY
J A Jones Hoober Observatory Lea Brook Lane, Wentworth, S62 7SH
20 March at 7.30am
www.msas.org.uk

8. ORWELL ASTRONOMICAL SOCIETY (IPSWICH)
Isaacs on the Quay Ipswich, 7 Wherry Quay, Ipswich, Suffolk, IP4 1AS
20 March at 8am
www.oasi.org.uk

9. KNOWLEDGE OBSERVATORY
Wigg Island Visitor Centre, Runcorn, Cheshire, WA7 1PJ
20 March at 8am
www.theknowledgeobservatory.co.uk

10. SCOTTISH DARK SKY OBSERVATORY
Nr Loch Doon, Dalmelington, East Ayrshire
20 March at 8am
www.scottishdarkskyobservatory.co.uk

11. FLAMSTEED ASTRONOMY SOCIETY
Royal Observatory Greenwich, Blackheath Avenue, London, SE10 8XJ
20 March at 8.30am
www.flamsteed.info

12. SWANSEA ASTRONOMICAL SOCIETY
Waterfront Museum, Oystermouth Road, Swansea, SA1 3RD
20 March at 9am
www.swanastro.org.uk

13. SNOWDONIA NATIONAL PARK AUTHORITY
National Park Offices, Penrhyndeudraeth, Gwynedd, LL48 6LF
20 March at 5pm
www.snowdonia-npa.gov.uk

14. BAYFORDBURY OBSERVATORY
Lower Hatfield Road (B158), Hertford, SG13 8LD
20 March at 6pm
www.herts.ac.uk/bayfordbury

15. BRITISH INTERPLANETARY SOCIETY
Droitwich Library, Victoria Square, Droitwich Spa, WR9 8DQ
21 March at 9.30am
www.bis-space.com

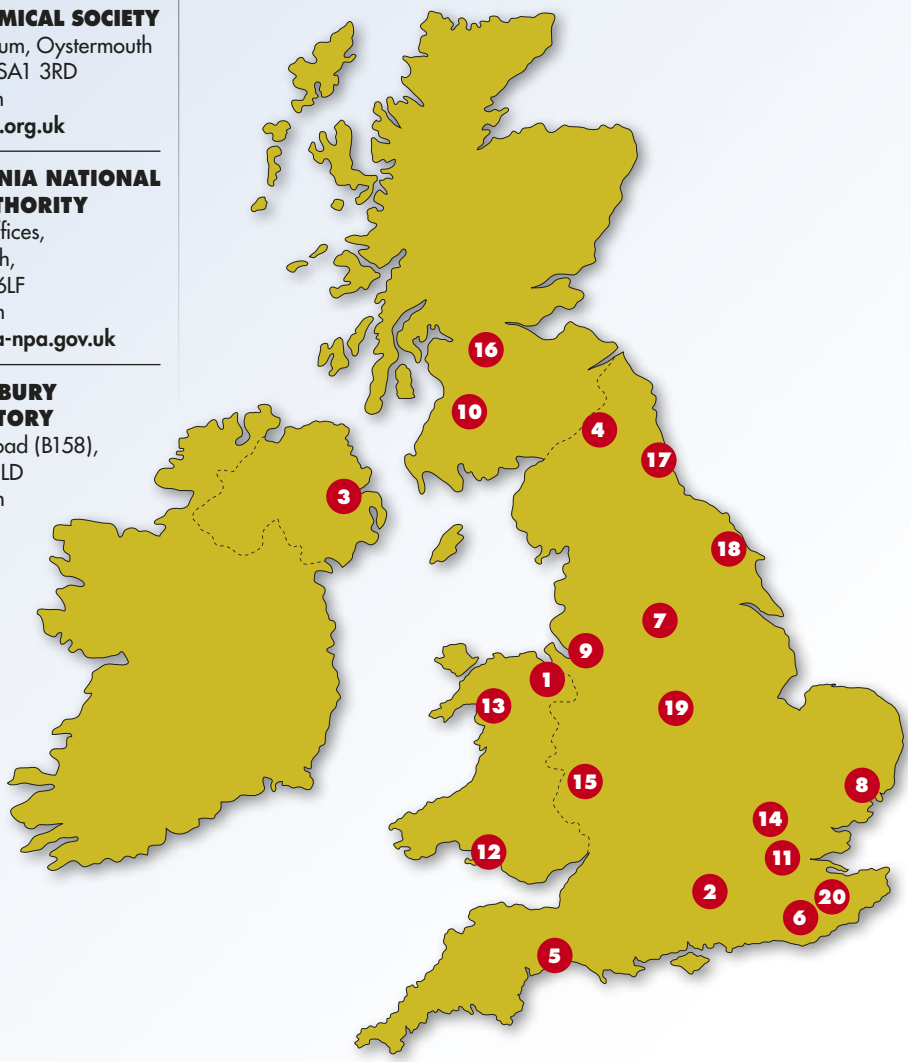
16. LANARK VISITOR CENTRE SCOTLAND
South Lanarkshire, ML11 9DB
21 and 22 March at 5pm
www.newlanark.org/visitorcentre

17. SUNDERLAND ASTRONOMICAL SOCIETY
Cygnus Observatory, WWT Washington Wetlands Centre, Pattinson, Washington, Tyne and Wear, NE38 8LE
21 March at 6.30pm
www.sunderlandastro.com

18. FORESTRY COMMISSION ENGLAND
Dalby Vistior Centre, Low Dalby, Dalby Forest, YO18 7LT
21 March at 8pm
www.forestry.gov.uk/forestry

19. EAST MIDLANDS STARGAZERS
Long Eaton School, Thoresby Road, Long Eaton, Nottingham, NG10 3PN
25 March at 6pm
www.eastmidlandsstargazers.org.uk

20. ASHFORD ASTRONOMICAL SOCIETY
Woodchurch Memorial Hall, The Green Front Road, Woodchurch, Ashford, TN26 3QB
28 March at 7.30pm
www.ashfordastro.org.uk



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The writers

MARK TOWNLEY

Solar expert Mark explains some of the simple ways you can project the eclipse and offers advice on imaging the event.

LYN SMITH

BAA Solar Section director Lyn Smith delivers some top tips on projecting the eclipse using a regular refracting telescope.

MARK PARRISH

Craftsman Mark is a regular on our *How to* pages. Here he reveals how to make a solar funnel to view the eclipse with a telescope.

PETE LAWRENCE

You can even view the eclipse through the eyepiece of most scopes safely if you have a white light filter. Pete shows us how to make one.

KIERON ALLEN

Got the ideas but not the right kit? Kieron rounds up some of the astro accessories you could use to get a great view.

Experience the eclipse

From solar scopes to kitchen implements, there are a multitude of ways to see this month's solar eclipse from the UK

On 20 March, observers in a slim slice of the northern hemisphere will be treated to one of nature's most impressive phenomena – a total eclipse of the Sun. This rare spectacle will not be visible again from Europe until 2026; even if you can't make it to the Faroe Islands to glimpse totality, the entirety of the UK will be treated to an impressive partial event.

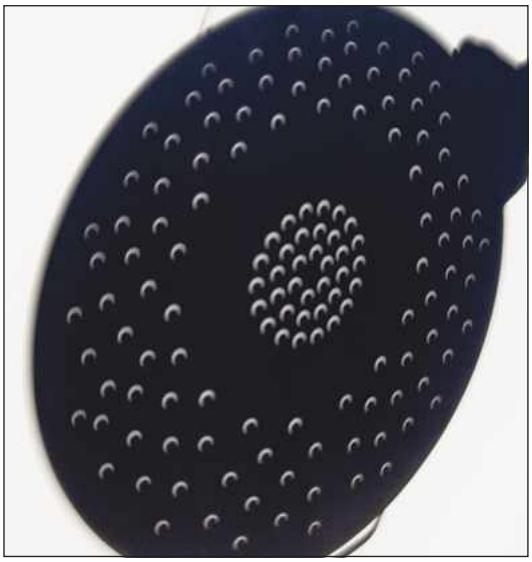
Eclipse times and coverage will vary from north to south. In Edinburgh the event will begin at 08:30 UT, with greatest eclipse at 09:35 UT when the Sun will be 93 per cent covered. From Manchester, the eclipse begins at 08:26 UT with maximum eclipse at 09:32 UT and coverage a little under 89 per cent. In London there'll be an 84 per cent eclipse, beginning at 08:24 UT and peaking at 09:30 UT.

To see the action find a clear southeasterly horizon – at greatest eclipse the Sun will be about as high in the sky as stretching out your thumb and little finger and holding it at arm's length, with the lower digit on the horizon.

This display of celestial mechanics is a must-see astronomical event. Read on to discover the many ways to experience it, and for more advice on timings turn to this month's *Sky Guide*.

BE SAFE

It's important to view any eclipse safely as the Sun can cause serious damage to your vision. Never look directly at the Sun without the protection of a certified solar filter or a pair of dedicated eclipse glasses manufactured for this purpose. Simply put the eclipse glasses on and you can watch directly as the Moon gracefully covers up more and more of the Sun. Just check before you put them on that there are no scratches or pinprick holes on the lenses.



▲ A kitchen colander can fulfil the same role as a pinhole camera, the crescents cast matching the eclipse phase

PROJECTION THROUGH A COLANDER

BY MARK TOWNLEY

SIMPLY HOLD UP a kitchen colander during an eclipse and you will see that myriad small crescents – corresponding to the eclipsed phase of the Sun – are cast in the shadow. Each hole acts in the same way as a pinhole camera, projecting an inverted image of the Sun, and this works even if the holes are not round. This effect can also be seen when sunlight shines through leaves on a tree or other foliage, with the gaps between leaves acting as pinholes and creating crescents of light in the shade on the ground.

Casting the image onto a white piece of card held about 50cm away will increase the contrast, making the event easier to see, however any light-coloured surface will work. Try varying this distance to find the sharpest image, as the size of the holes in different colanders will affect the view. This method is the cheapest and easiest way for a group of people to simultaneously view the eclipse and its progress with no risk to either eyesight or equipment.

The results can be easily photographed using any conventional camera. The only downside is the size of the crescents are quite small. Increasing the distance between the colander and the projection screen will make the crescents larger, but also less defined. As such, other than the crescent itself, no details such as sunspots can be seen.

PROS

- Cheap and easy
- Great for large groups of people

CONS

- Views are quite small
- No detail can be seen apart from the crescents

BBC X 2, ISTOCK X 2, ROBERT COUSE-BAKER

PROJECTION THROUGH BINOS

BY MARK TOWNLEY

TO GET A larger, brighter image and detail on the eclipsed Sun you need optics of some sort. The easiest way is to use binoculars to project an image onto white card. To keep the image steady, mount the binoculars on a tripod. You'll also need a 'light shield' to keep the projected image in the shade.

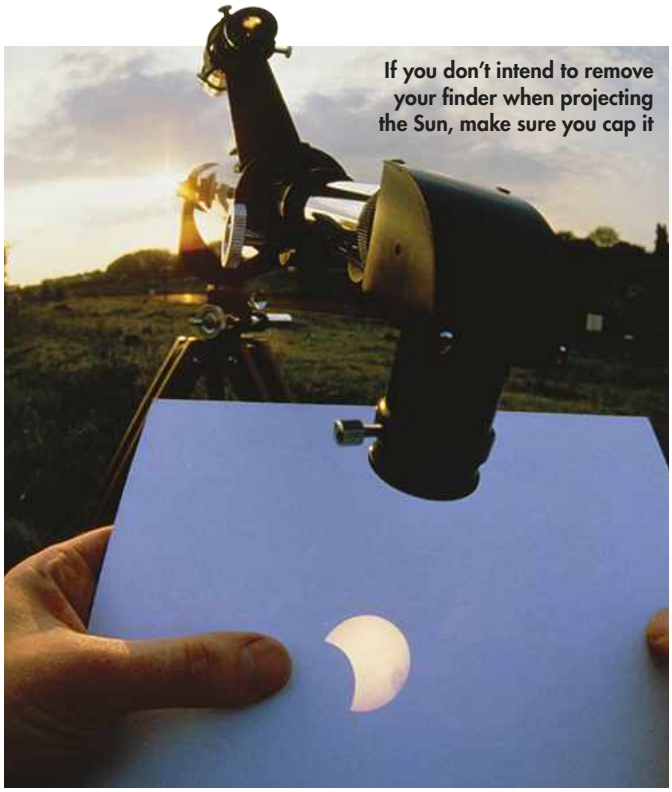
Create this shield by placing the binoculars, objective lenses down, on the centre of a sheet of thick card. Trace around the lenses and then cut out the resulting circles to create holes in the middle of the card. With the binoculars mounted on the tripod, fix the card around the objective lenses using gaffer tape (as below), sealing any holes around the card edge where light could leak through. Cover one of the objective lenses with the lens cap.

Aim the binoculars at the Sun without looking though them – this can be tricky so it is worth practising this before the eclipse. Hold a piece of white card about 50cm behind the binoculars and focus until a sharp image is reached. Don't put anything in the concentrated light beam coming from the eyepiece as this is hot enough to burn. With sharp focus, this method will easily show any sunspots along with their darker umbra and penumbra.

PROS
- Straightforward to set up
- Brighter and more detailed images than the colander method

CONS
- Aiming at the Sun is tricky
- Care must be taken with concentrated sunlight

▲ **Fitting your binoculars with a 'light shield' is essential if you want to be able to see the eclipse event you are projecting**



If you don't intend to remove your finder when projecting the Sun, make sure you cap it

PROJECTION THROUGH A TELESCOPE

BY LYN SMITH

ANOTHER WAY TO project the eclipse is through a telescope. Small refracting telescopes with 2- to 4-inch apertures are by far the best instruments for this task, as those with larger apertures are in danger of overheating unless a full-aperture filter is used.

If this is the first time you've used this method to view an eclipse, it's probably best not to experiment with a large-aperture telescope. Also make sure that you use a Huygens eyepiece, a design that doesn't contain cement, which could melt with the heat, and that any finderscopes you have attached are either removed or capped.

First roughly align your refractor with the Sun by moving it until its shadow on the ground is at its smallest. Keep the dust cap on as you do so. Place a piece of white card behind the eyepiece, using a projection box or music stand to hold it in the desired position, and look for a rounded shadow. Never look through the eyepiece in your attempts to find the Sun.

PROS
- No additional equipment is required
- Easy and quick to set up
- Simple to orientate to the Sun's disc

CONS
- Great care is needed, as unfiltered sunlight comes through the eyepiece
- There is a danger of damage to larger telescopes and some eyepieces
- Fine detail can be difficult to see clearly

Our funnel offers a unique way of viewing this amazing event

VIEWING THROUGH A DIY SOLAR FUNNEL

BY MARK PARRISH

A SOLAR FUNNEL is a hollow cone with an eyepiece fitted in the narrow end and a translucent screen at the other. Because the eyepiece is internal, there is no way for you to accidentally look into the light path.

It's easy to build one yourself. The length of our funnel is calculated to suit refracting telescopes with apertures up to 3 inches and focal lengths of 300-1,000mm. If your scope's main lens is larger than 3 inches we'd recommend reducing the effective aperture by using a cardboard mask with a smaller hole of 2 inches cut in the centre and taped over the dew shield. The eyepiece inserted into the funnel determines the size of the image; we found that any eyepiece with a focal length between 12mm and 25mm produced acceptable results.

Install the funnel after capping your main lens and any accessories, and with your eyepiece fitted. Position it in your scope's focuser, ensuring that the eyepiece is firmly fixed in the funnel and gripped by the focuser. Next, align the telescope with the Sun by lining up the scope so its shadow becomes small and round. When it is, you should be pointing towards the Sun. Remove the lens cap (or uncover the opening of your aperture reducer) and you should see a bright image of our star somewhere on the screen. Just sit back and wait for the show.

PROS

- Simple and easy to set up
- Cheap and easy to source materials
- Safe to use

CONS

- Unsuitable for Newtonian telescopes
- Requires construction and is susceptible to damage

TOOLS AND MATERIALS

Cardboard and paper Three pieces of thin, A4 packaging card. Tracing paper works really well for the screen.

Eyepiece Any low-cost eyepiece with a focal length in the 15-25mm range.

Finish Matt black spray paint internally. Use gloss paint or sticky-backed plastic externally.

Tools and sundries: Craft knife, steel ruler, glue gun or strong craft glue, spray adhesive or glue stick, black duct tape or electrical tape, elastic bands.

STEP BY STEP GUIDE

Tap here to see a step-by-step guide to building this solar funnel

VIEWING THROUGH A WHITE LIGHT FILTER

BY PETE LAWRENCE

ONE OF THE safest ways to view the eclipse is to fit a white light filter over the front of your telescope. The resulting view has good contrast and neutral colour. These filters are relatively simple to make using sheets of solar film cut to size. Baader's AstroSolar Safety Film is available in two grades: OD 3.8 is for imaging only, while OD 5.0 is suitable for visual observing and imaging. OD stands for 'optical density', with higher numbers giving you dimmer images. Once you've made your filter, you must check it for pinprick holes and tears each time you're about to fit it. If you find any, discard the filter and make a new one.

When you use the filter, it's important to also remove or cap your telescope's finder. This prevents it from being damaged by the Sun's intense rays and removes the urge to look through it to line up the main instrument. Always make sure the telescope is pointing away from the Sun before fitting the filter. When you're done observing, do the same – aim the telescope away from the Sun before removing it.

If your telescope aperture is too big to entirely cover with solar film, you can use a mask made from stiff card to cover over it; then cut a smaller hole in this mask and cover that with solar film. Make sure that the mask fits over the entire aperture and that no light can leak around its edges. For telescopes with a central obstruction, such as reflectors or Schmidt-Cassegrains, cut the aperture hole off-centre so the secondary mirror doesn't block it.

PROS

- Can be adapted to fit any telescope
- Quick and portable option

CONS

- Requires construction
- Materials used are perishable

TOOLS AND MATERIALS

Card An A2 sheet of thin card cut into 50mm-wide strips forms the filter's slip-on wall.

Sticky tape Both normal and double-sided tape are invaluable for easy construction.

Solar film The main filter material is generally available in A4 sheets, but is sometimes available in larger rolls.

White light filters reveal great detail – so you can use them for regular solar observing after the eclipse

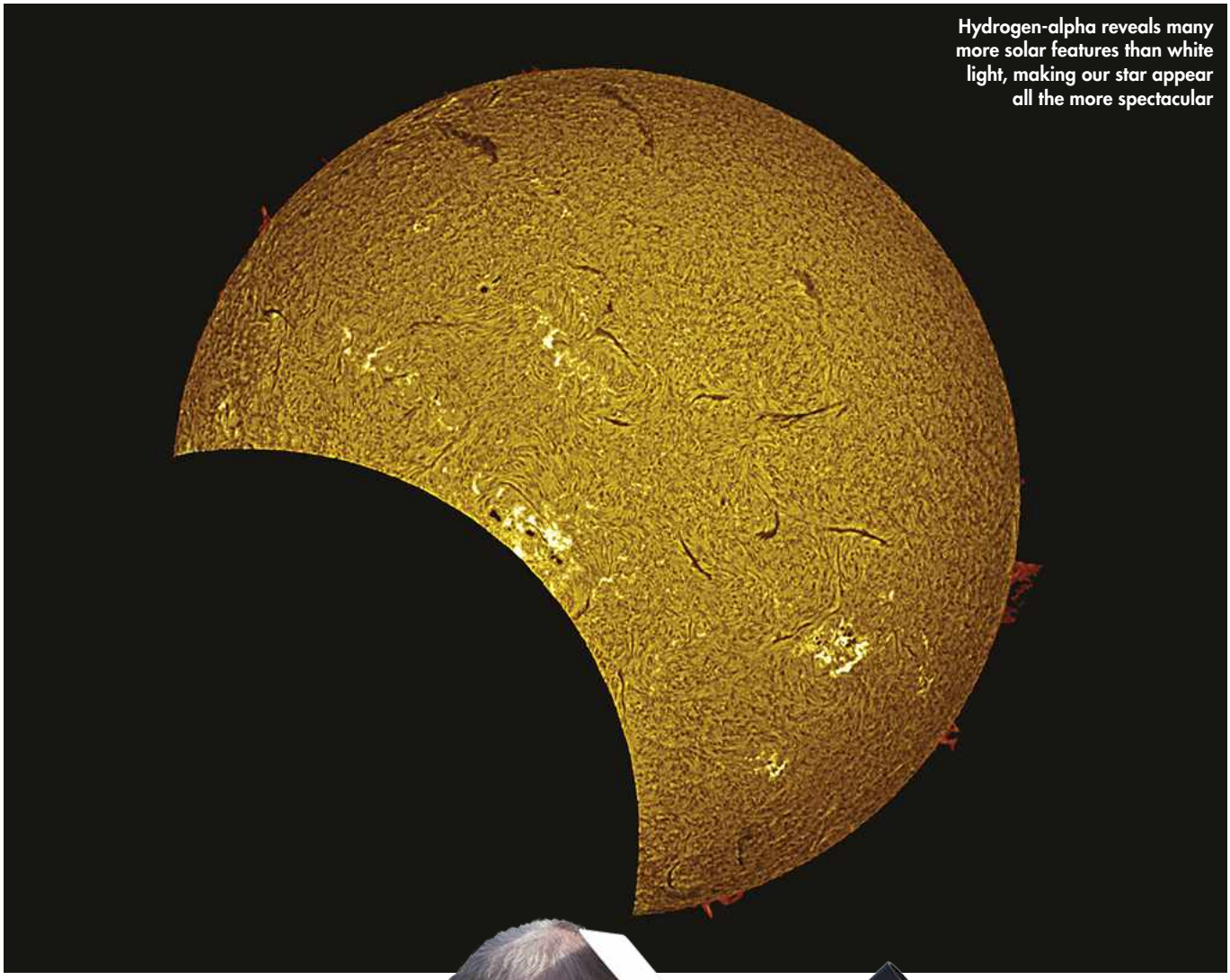
STEP BY STEP GUIDE

Tap here to see a step-by-step guide to building a solar filter

BBC X 2, ISTOCK, PETE LAWRENCE X 2, ALAMY, JON HICKS

WHAT YOU'LL SEE IN HYDROGEN-ALPHA

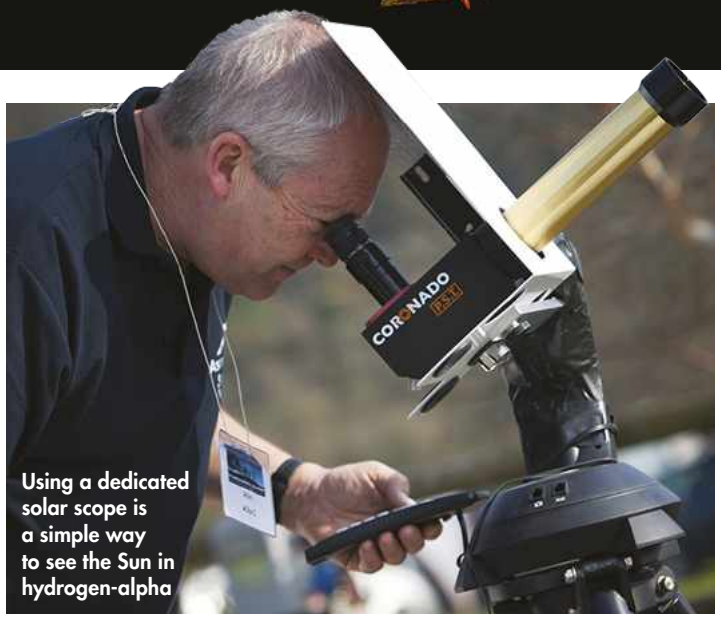
BY MARK TOWNLEY



Hydrogen-alpha reveals many more solar features than white light, making our star appear all the more spectacular

FOR THE BEST views of the eclipse hydrogen-alpha is the way to go, with a variety of manufacturers offering dedicated hydrogen-alpha telescopes or filter sets that fit onto regular telescopes.

A dedicated hydrogen-alpha refractor such as the Coronado PST (£695) offers the easiest and most affordable way to see our star in this way. All you need is a suitable mount and eyepiece to get observing. If you already own a good refractor or Schmidt-Cassegrain telescope, it is possible to buy an etalon filter system to go on the objective lens, and used with a blocking filter on the rear of the scope it offers excellent views. However, these are more expensive than dedicated hydrogen-alpha instruments and in addition you will need an adaptor plate made up to fix the etalon to your telescope.



Using a dedicated solar scope is a simple way to see the Sun in hydrogen-alpha

Whichever method you choose hydrogen-alpha views are simply stunning, with a wealth of features on show. Around the limb of the Sun you'll see prominences, huge clouds of plasma held above the solar surface by magnetic fields. If these are visible on the day of the eclipse and are in the right place on the solar limb, they may be the first thing to disappear just before the moment of first contact. As the Moon slowly passes over the face of the Sun it will cover features only visible in hydrogen-alpha light, including active regions, flares, plage and filaments.

PROS

- Great levels of detail
- Options available for using regular scopes

CONS

- More expensive than other methods

ECLIPSE EQUIPMENT

BY KIERON ALLEN

▲ DAYSTAR H-ALPHA EYEPIECE FILTER
daystarfilters.com; £795
This eyepiece-end filter allows you to convert a f/4-f/9 refractor into a solar scope. If its aperture is over 3 inches, you'll also need an energy rejection filter over the front lens.

SOLAR WEDGE ▶
luntsolarsystems.com; £179
The solar or Herschel wedge is used to refract the light from the Sun away from the optical path of your eyepiece for safe solar observing. Use a solar wedge in your refractor for stunning white light views.

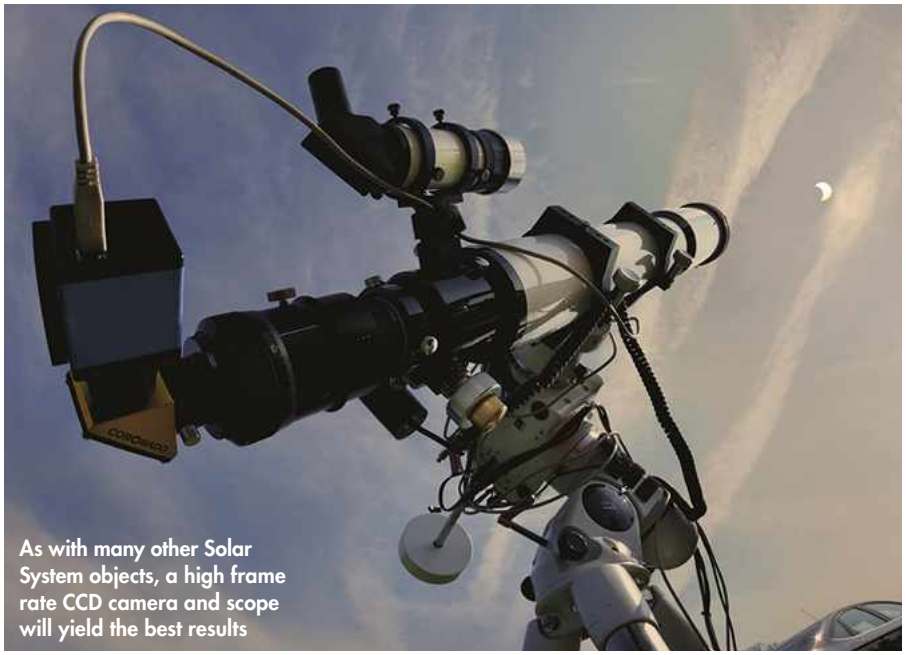
SOLAR FINDERSCOPE ▶
telescope.com; £85
The solar filters built into these finders allow you to safely align your instrument with our star. Coupled with a hydrogen-alpha or a white light filtered scope, this is the perfect aid to accurate solar observing.

▼ BAADER ASTROSOLAR SAFETY FILM
baader-planetarium.com; £18
The vision-protecting element of a white light solar filter, this film is easy to handle and easy to replace if it becomes scratched or torn while in storage.

H-ALPHA TELESCOPE ▶
luntsolarsystems.com; £7,995
Dedicated hydrogen-alpha solar scopes are expensive compared to white light filters but reveal different detail. They are worth investing in if you intend to take up solar observing seriously.

IMAGING THE ECLIPSE

BY MARK TOWNLEY



As with many other Solar System objects, a high frame rate CCD camera and scope will yield the best results

A NUMBER OF methods can be used to photograph an eclipse. The most straightforward is to hold a smartphone or simple digital camera to the eyepiece of a white light filtered refractor and take an afocal shot; note that this works best if the filter covers the scope's entire aperture. This method also captures any sunspots present. For a more detailed view in white light, use a DSLR camera with a Herschel wedge at prime focus: this will not only create a record of any sunspots but also reveal the irregular limb of the Moon. Keep the ISO setting on the camera low as this will reduce noise in the final image.

Stunning shots can be recorded using a narrowband hydrogen-alpha or calcium-K filter system, but the best results are often obtained by taking several images using a monochrome CCD camera and stacking the images using RegiStax or DeepSkyStacker. As the Moon's disc moves continuously across the face of the Sun during an eclipse, each imaging run needs to be no more than three of four seconds long or less than 100 frames to avoid blurring, with only the 50 best frames being stacked for the final image.

The key to successful imaging using any of these methods is to practise your chosen technique several times before the eclipse to familiarise yourself with the process, paying particular attention to making sure you maintain sharp focus. To capture a sequence that shows eclipse phases, start imaging at first contact and then at intervals of 10-15 minutes, making sure to include maximum eclipse and fourth contact. These images can be turned into an animation or a timeline to show its progress.

ISTOCK, PAUL WHITFIELD, PETE LAWRENCE, LUNT, ORION, JON HICKS

LIVE around the world with LIZ BONNIN

For the past four years presenter Liz Bonnin has reported from all over the world for *Stargazing LIVE*. We talk to her about her experiences

INTERVIEWED BY ELIZABETH PEARSON


Liz has travelled far and wide for TV; here she is at Mauna Kea in Hawaii.

How did you first get involved with *Stargazing LIVE*?

I was filming a programme about space archaeology in Egypt and my agent gave me a call and said there's this new astronomy show with Brian Cox and Dara Ó Briain, and they'd like you to do the live feeds. I remember shouting my head off in excitement! I was so delighted but I was also a little bit apprehensive because it's not really my background – I studied biochemistry and animal biology. But with *Bang Goes the Theory*, the science show I'd been doing for several years at that point, I'd covered many different sciences and topics, including a lot of physics. And I'd always been fascinated by space exploration and astrobiology. So I said "Yes, please let me do it".

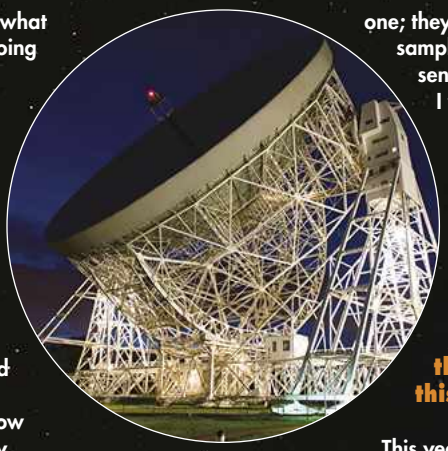
Has doing the show given you a new appreciation of space?

Absolutely. It's sometimes quite hard to put into words how awe inspiring all of these incredible scientists and all these places are. For me it was an incredible opportunity. One of the things I love about my job working with BBC Science is that I get to meet scientists in different disciplines who are working at the cutting edge of research. It's been a really thrilling experience, but for me with a fairly broad knowledge of astronomy it's fabulous to just step in and learn what different scientists are doing around the world.

Sounds like you've enjoyed your time on the show. Do you have a favourite moment so far?

We went to NASA's Jet Propulsion Laboratory one year and talked to lead engineer Adam Steltzner about how they landed the Curiosity rover. He invited us for a drink one evening. He was there with his colleagues and they were just bantering about one of the new missions – discussing what they needed to do, what they needed to test, did they need a vacuum, how were they going to land. And for them these were just normal conversations.

They had only just landed the Curiosity rover and they were looking at the next one; they were looking at sampling and returning, sending a man out there. I was sitting there with my team and we were just pinching ourselves! That was just such a momentous occasion.


▲ Liz will be at Jodrell Bank for this year's *Stargazing LIVE*

You've been all over the world with *Stargazing LIVE*, so where are they sending you this year?

This year I'm going to be at Jodrell Bank [where the main show is based] for one or two of the evenings, then getting on a plane and going to the Faroe Islands for the eclipse on 20 March, before journeying back to Jodrell that evening. I'm joining the eclipse chasers, though we are going to be in a plane so there's no risk of us being hindered by cloud cover. We're using the same plane as we did for the aurora hunt last year but


Liz with the *Stargazing LIVE* team in 2014 just before boarding the plane to go aurora hunting

LIZ BONNIN X 2, MARK PAYNE-GILL, ISTOCK X 2

▲ Ever the adventurer, Liz isn't afraid to get her feet wet whatever the weather

it's been kitted out with different pieces of equipment. On 20 March we'll be getting up in that plane and trying to capture the best images of the eclipse that we can.

Last year you went aurora hunting in Norway and captured some amazing live views of the Northern Lights. Were you ever worried that you wouldn't see anything?

It was one of the most ridiculous experiences we've ever had. We weren't convinced that it was going to work. The night before there weren't any aurorae, things were going wrong and everyone was quite stressed about it. On the night we were standing there thinking "It's okay, it's our first night, we've got another chance tomorrow, so let's not panic". Then literally 20 minutes before we were about to go on air, the clouds cleared and there it was. It was amazing. It's a live show, so we'd obviously prepared ourselves for no aurorae on any of the nights, but as luck would have it we had an aurora every single one of them.

With all the incredible things you've seen, is there anywhere in the world you'd still like to go?

I very cheekily ask every year if we can go to the Atacama Desert in Chile. We were talking about it for this year again, but obviously with the eclipse it was a no-brainer; we were going to cover that. I've always wanted to go to Chile, to see the work that goes on at the observatories. It would be a dream come true. But who knows? Maybe next year.

What if you could go anywhere out of this world?

The very edge of our ever-expanding Universe – the moment of the Big Bang – to see the instant it all came together and see what theory is actually correct. That would be quite something. Isn't that what everyone wants to know? Isn't that the Holy Grail?

Is it important to you to share space and science with the general public?

That's why I do what I do. *Bang Goes the Theory* went into production just as I finished my masters and I just jumped at the chance of being able to share that information with people. Somewhere along the line education can lose that enthusiasm and that natural curiosity of the world. If I can help to reignite that curiosity then I'm thrilled to be able to do that.

I want to go back and do my PhD at some point, but I think we need to discuss what we do as scientists. There is a danger that if we don't share what we do with the public, or help them to understand the natural world, then we're doing something wrong. *Stargazing LIVE* is exactly the perfect vehicle to share the research that we do.

Are you hoping to stay with the show for a long time?

Every year I keep my fingers crossed that I'll get the call. We are hoping that we can make many more series every year. Fingers crossed, we'll do many more in the future. S

"I think we need to discuss what we do as scientists. *Stargazing LIVE* is the perfect vehicle to share the research that we do"

Tring Astronomy Centre

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The Sky Guide March

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

PETE LAWRENCE

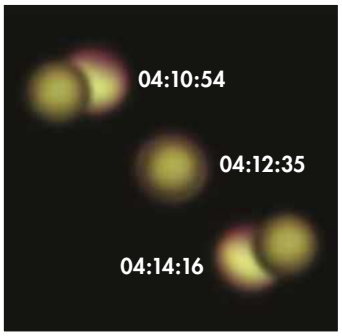
The Moon will appear to cross the face of the Sun on 20 March from certain locations on Earth. The path of totality passes tantalisingly close to the UK resulting in a large partial eclipse. The farther northwest you are, the greater the coverage, but even from the southeast corner of the UK a substantial partial eclipse can be seen.

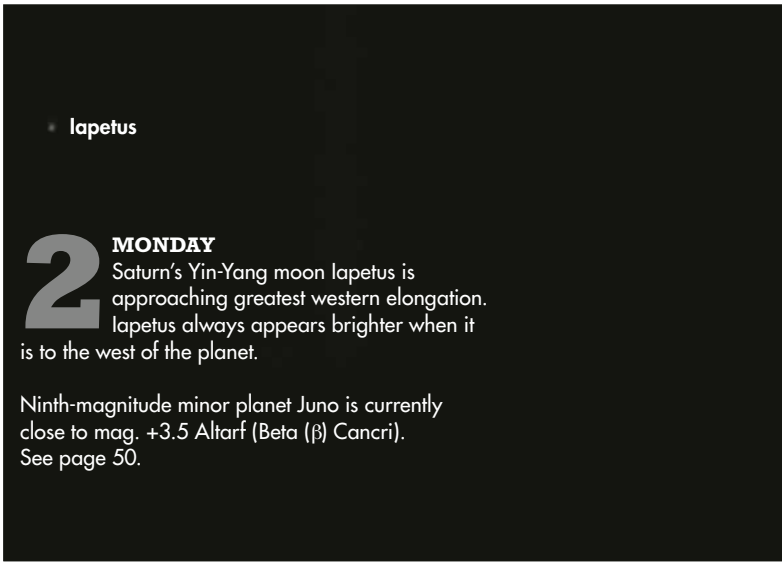
Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity

1 SUNDAY ▶
Galilean moon Europa will pass across the face of Io between 04:09:38 UT and 04:15:32 UT. Mid-occultation occurs at 04:12:35 UT, when Europa will be concentrically located within the Io's disc. Jupiter will be 19° up in the western part of the sky at this time.





2 MONDAY
Saturn's Yin-Yang moon Iapetus is approaching greatest western elongation. Iapetus always appears brighter when it is to the west of the planet.

Ninth-magnitude minor planet Juno is currently close to mag. +3.5 Altarf (Beta (β) Cancri). See page 50.

3 ◀ TUESDAY
A 93%-lit waxing gibbous Moon sits slightly over 6° southwest of Jupiter in the early hours. As an added bonus, the Moon occults mag. +4.3 Acubens (Alpha (α) Cancri). The star disappears around 03:25 UT, reappearing an hour later from behind the Moon's bright limb.

4 WEDNESDAY
The brightest naked-eye planet meets the dimmest this evening. Venus and Uranus will be visible low in the west after sunset. Look for Venus around 20:00 UT; the star-like dot 6 arcminutes below and slightly left of it is Uranus.

12 THURSDAY
A 65%-lit waning gibbous Moon sits 2° to the northwest of Saturn at 05:00 UT. At this time the pair are located just north of the claws of Scorpius, the Scorpion.

13 FRIDAY
The Moon is out of the way for the next couple of weeks, making this a good time to try and catch some of the fantastic galaxies that lurk near the back legs of Leo, the Lion. Turn to this month's *Deep-sky tour* on page 56 to see if you can find them.

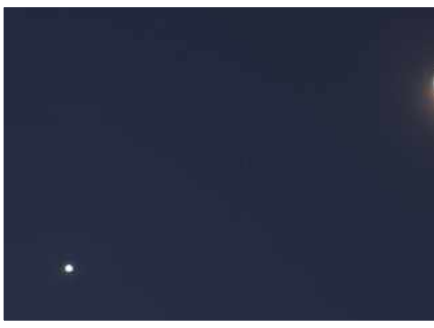
14 SATURDAY
Lunar libration favours the southwest limb of the Moon from 10-16 March. The best view of the region, which contains the fabulous Mare Orientale, will be had in the early hours of this morning.

17 TUESDAY ▶
The delicate constellation of Coma Berenices is well placed around midnight. It contains a number of beautiful deep-sky objects, including naked-eye open cluster Melotte 111, 7th-magnitude globular M53 and the superb edge-on galaxy NGC 4565, pictured.

20 FRIDAY
A partial solar eclipse can be seen from the whole of the UK between 08:15 UT and 10:50 UT. Actual start and end times will vary slightly with location. Turn to page 50 for details on when to observe this special event, page 36 for how to observe it and page 60 for how to photograph it.

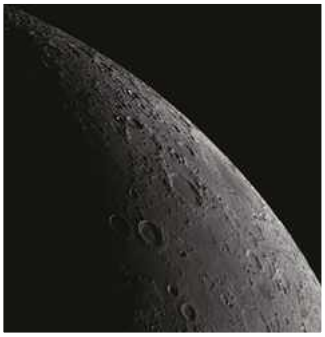
The spring equinox occurs at 22:45 UT.

21 SATURDAY
A delicate 2%-lit waxing crescent Moon sits 2.3° to the west of Mars this evening, though the tilt of the sky means that it will appear below and slightly to the right of the planet. View them from around 19:30 UT.



24 TUESDAY ▶
Lunar libration is favouring the northeast limb at the moment, bringing features such as the Mare Humboldtianum into view.

Ganymede will partially occult Callisto between 00:10:26 UT and 00:18:45 UT.



PETE LAWRENCE X 8

11 WEDNESDAY ▶

Mars and Uranus meet this evening. The pair are best seen against a dark sky at 20:00 UT, but they will only be around 3° up, in the west. They will be 17 arcminutes apart, nearly three times the distance between Uranus and Venus on the 4th.

18 WEDNESDAY

The intriguingly named Realm of Galaxies is well placed around midnight, and with the Moon out of the way this is a great time to try out some galaxy hopping. A small scope will typically show many of the brighter ones as smudges.

22 ◀ SUNDAY

There's a lovely view of mag. –3.9 Venus and an 8%-lit waxing crescent Moon in this evening's sky over towards the west. They will be less than 4° apart and best seen after 19:00 UT.

23 MONDAY

The Moon will have moved farther from Venus this evening, but the duo will be striking nevertheless. Look west after sunset. The Moon's phase will have increased to 15%-lit and as the sky darkens it should exhibit earthshine.

29 SUNDAY

The clocks go forward by one hour at 01:00 UT, marking the start of British Summer Time (BST).

30 MONDAY

Tonight the 81%-lit waxing gibbous Moon sits 8.5° southeast of Jupiter and they form a triangle with mag. +1.4 Regulus (Alpha (α) Leonis). This impressive celestial geometry can be seen as soon as the sky begins to darken, halfway up the sky looking south.

What the team will be observing in March

Pete Lawrence "With the first decent partial solar eclipse visible from the UK in many years, all eyes will be glued skyward. I'll be on a cruise ship in the middle of the North Atlantic trying to catch the event as a total."

Paul Money "I'll be looking out for the conjunctions between Uranus and Venus on the 4th then Uranus and Mars on the 11th. I love these close encounters between the planets!"

Steve Marsh "I'll definitely be turning my scope moonwards and trying to produce a mosaic of some tricky lunar limb features towards the end of the month"

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. On 29 March, the UK swtiches to British Summer Time (BST).

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

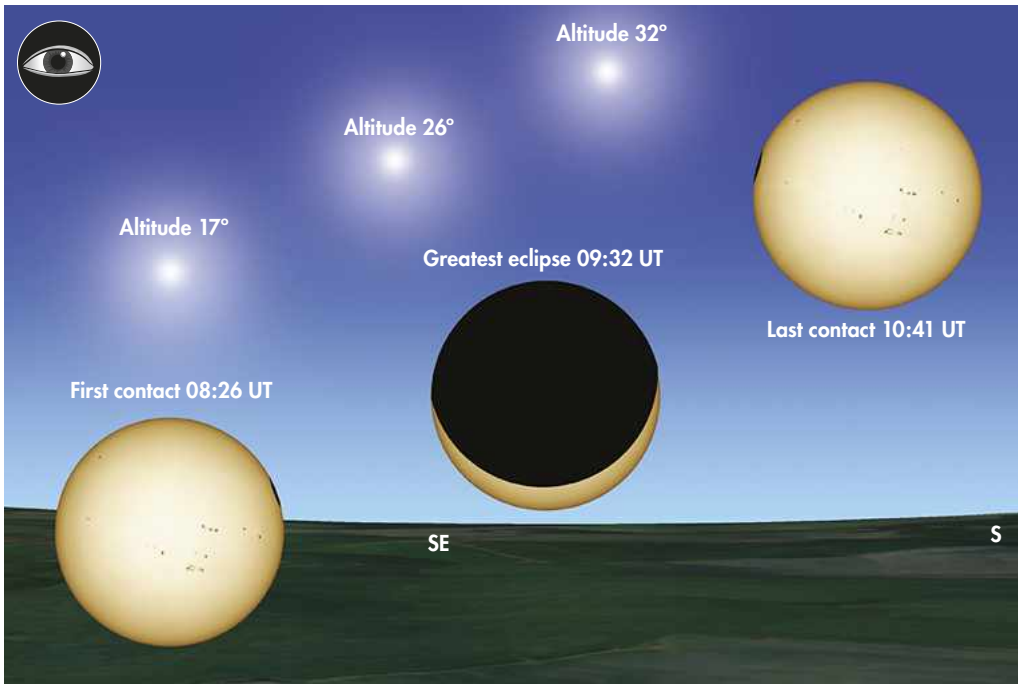
If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS...

3 top sights

A partial eclipse of the Sun

WHEN: 20 March, 08:15 UT to 10:50 UT



Times and positions correct for the centre of the UK; times will vary by a few minutes depending on location

THE UK HAS not experienced a decent solar eclipse for some time, but that is about to come to an end. On the 20th the Moon will appear to pass across the face of the Sun producing a major partial eclipse as seen from the UK.

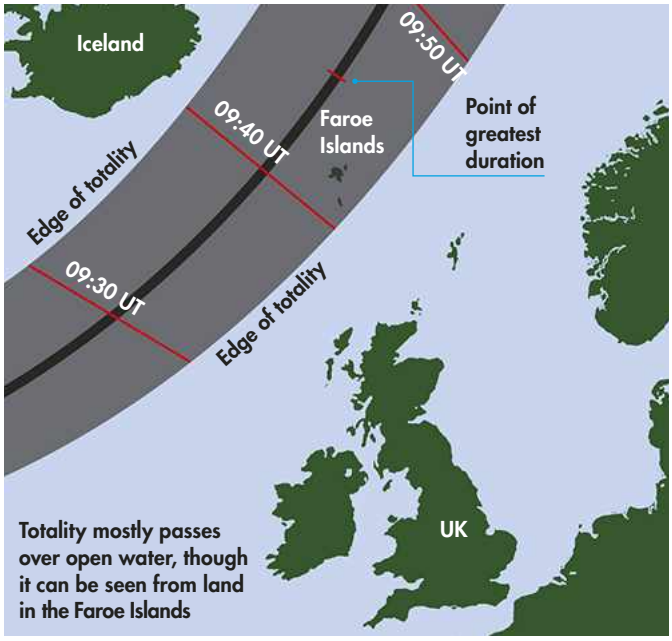
If you happen to be in the right place at the right time, this event is actually a total solar eclipse. The path of totality passes tantalisingly close to the UK, missing the northwest of Scotland by 240km. Totality mostly crosses the ocean, but can be seen from the Faroe Islands and the archipelago of Svalbard, to the north of mainland Norway.

The track's location means that the best partial, in terms of area of the Sun covered by the Moon's disc, will be seen from the northwest of the UK. As you head further southeast, the amount of partial coverage decreases. From the Isle of Lewis in the Outer Hebrides, the Moon covers 97.8 per cent of the Sun's disc by area. By contrast, in the southeast of the UK, the Moon covers 82.7 per cent of the Sun. This means that from anywhere in the UK, as long as the clouds keep away, a decent partial eclipse can be seen, and that's very exciting.

As ever with the Sun, it's imperative to observe the event in a safe way to prevent damage to your eyesight or equipment. The safest option is to use certified eclipse glasses like the ones included with this issue of *BBC Sky at Night Magazine*.

Unlike a total eclipse of the Sun, a partial eclipse is a relatively relaxed affair. From the centre of the UK mainland, first contact, when the Moon's disc makes its first impression into the Sun's, is at 08:26 UT. Maximum eclipse is at 09:32 UT and last contact occurs at 10:41 UT.

These times will vary across the whole of the UK but are contained in the envelope of 08:19 UT to 10:45 UT, so the variation is not that significant. The Sun's altitude will vary from around 17° at the start of the event to 33° at the end. At the point of maximum eclipse the Sun and Moon will be around 26° up in the southeast. This makes this eclipse the best placed event of its kind for some time. For details on how to capture an image of it, turn to page 60; for more ways to view the event, see page 36.



NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.

PETE LAWRENCE X4

Minor planet Juno passes through Cancer

WHEN: 8-25 March (to avoid the Moon)

MINOR PLANET JUNO is currently passing through the constellation of Cancer, the Crab, providing a good opportunity to locate this small member of the Sun's extensive family.

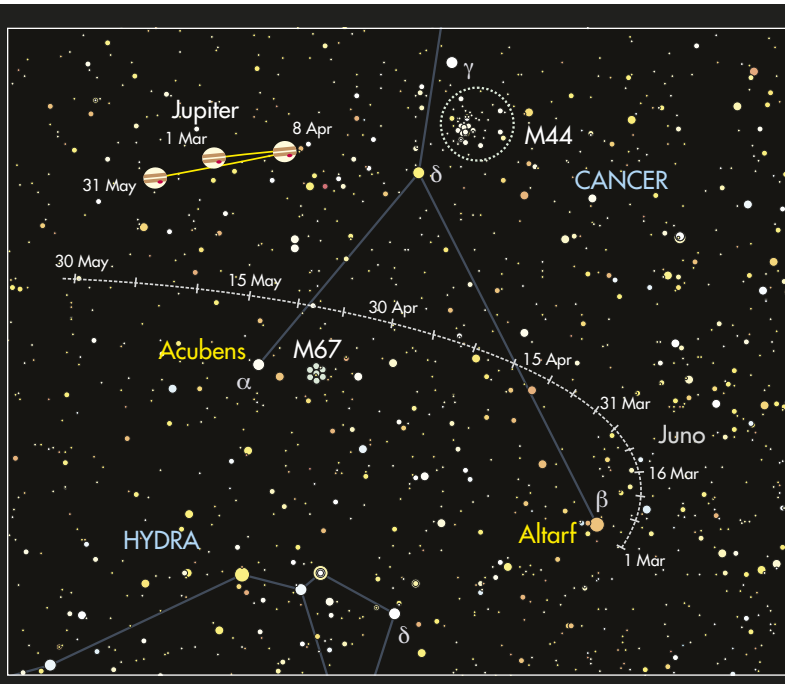
Juno was the third minor planet discovered after Ceres and Pallas, though Ceres has subsequently been reclassified as a dwarf planet. Juno has an irregular shape, measuring 320x267x200km, and is believed to be composed mainly of silicates. It's also believed to be the parent body of many of the meteorites that fall to Earth.

At the start of March, Juno is not too far from mag. +3.5 Altarf (Beta (β) Cancri), the star in the southwest corner of the inverted-Y shape of Cancer. The minor planet will be around mag. +8.8 at this time, so you will need a pair of binoculars at least to pick it out from the background stars.

Having said this, Juno will look exactly like a mag. +8.8 star when viewed, so it's necessary to employ an observational trick to guarantee that you've actually caught sight of it. That trick is to record Juno's position over the course of several nights.

Unlike the background stars, which stay in the same place, Juno's dot will appear to move. Its curving path will take it to the northwest of Altarf around the middle of the month, after which it will swing to the star's north. Throughout April it will pass approximately 5.5° to the south of the Beehive Cluster, M44, and in May 5° south of Jupiter.

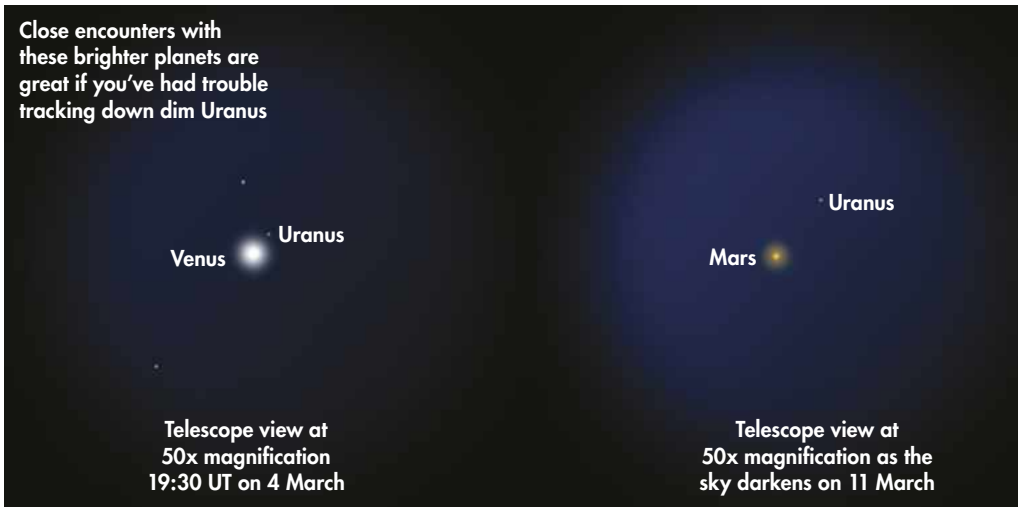
Juno's magnitude drops from +8.8 at the start of March to +9.5 at the beginning of April, fading again to +10.1 at the start of May. It drops only marginally throughout May, to end up at +10.5 by the end of the month.



▲ Juno arcs around Altarf in March, only moving away during April

Venus and Mars in conjunction with Uranus

WHEN: 4 March at 19:00 UT and 11 March as the sky darkens



THERE'S AN APPARENT meeting between the brightest and dimmest naked-eye planets this month on 4 March, when mag. –3.9 Venus will appear just 5 arcminutes from mag. +5.9 Uranus. This is a great opportunity for an unusual image of the pair, or to grab a view of distant Uranus if you've never seen it before. The magnitude difference between the two means that Venus will appear more than 8,000 times brighter than Uranus.

Use a telescope to view Venus around 19:00 UT on 4 March. It will be around 14° up in the west at this time and difficult to miss because of its piercing brightness. Uranus is the faint dot below and left of Venus, the 5-arcminute separation between them on this date equivalent to one-sixth of the apparent diameter of the full Moon. Note that mag. +1.3 Mars is also nearby, 5° below and right of Venus.

A few evenings later, on the 11th, it's Mars's turn to have a close encounter with Uranus. This one will be a bit harder to view as both planets will be lower on the western horizon as the sky darkens. They will be separated by around 17 arcminutes at 19:45 UT.

NEED TO KNOW

The size of objects in the sky and the distances between them are measured in degrees. The width of your little finger at arm's length spans about 1°.

The planets

PICK OF THE MONTH

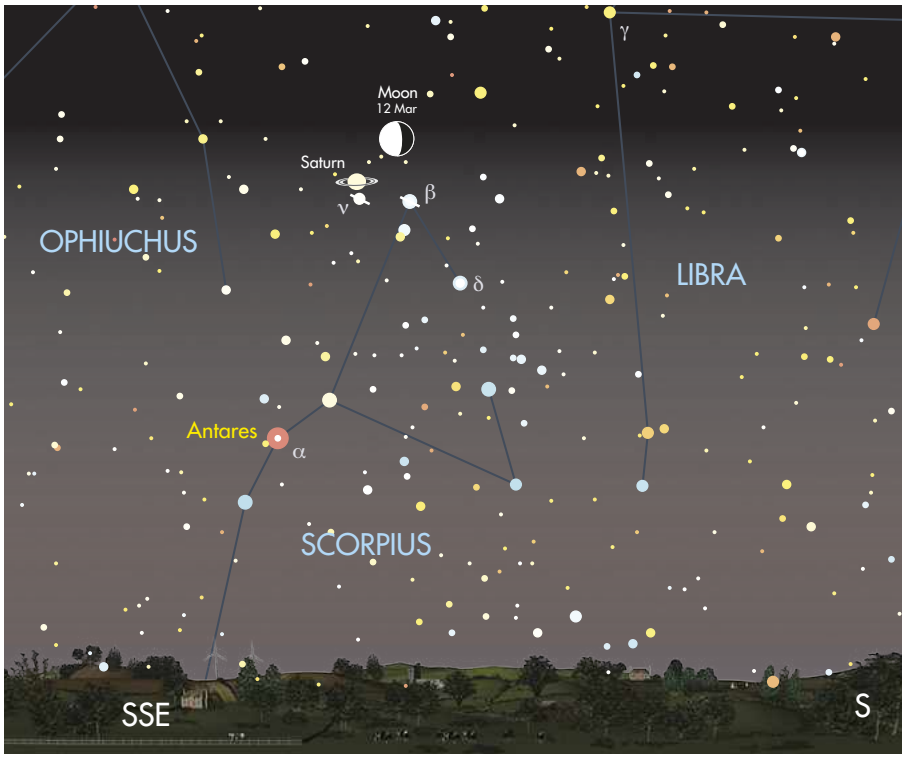
SATURN

BEST TIME IN MARCH:
31 March, 04:50 BST (03:50 UT)
ALTITUDE: 18°
LOCATION: Scorpius
DIRECTION: South
RECOMMENDED EQUIPMENT:
3-inch or larger scope
FEATURES OF INTEREST:
Rings, atmospheric features, moons

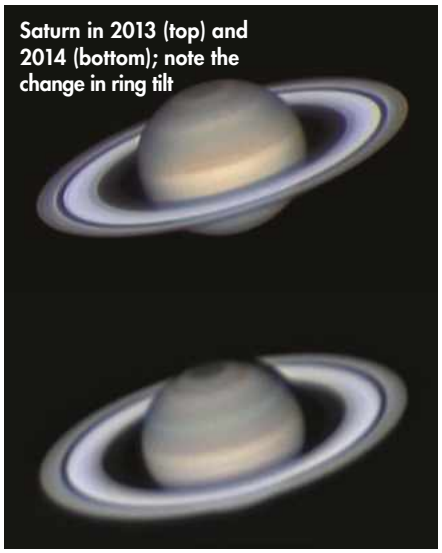
SATURN IS THE 'wow' planet of the Solar System – the one that makes everyone gasp when they get their first glimpse of it. This is, of course, due to the fantastic rings that encircle the planet's globe. Although some other planets in the Solar System have rings too, none come even close to being visible through amateur scopes. Saturn's, on the other hand, are relatively easy to see.

There's no getting away from the fact that Saturn is currently rather low as seen from the UK. This results from it residing along the part of the ecliptic which passes through the low-down southerly constellations of Scorpius and Sagittarius.

Being close to the horizon, our view of Saturn will suffer because of the thicker atmospheric layer we have to look through, but it's still possible to see the rings, which are currently tilted by 25° to the vertical in a way that lets us look at their northern face.



Saturn is low in Scorpius, mired in atmospheric murk; the Moon makes a close pass on the 12th



Saturn in 2013 (top) and 2014 (bottom); note the change in ring tilt

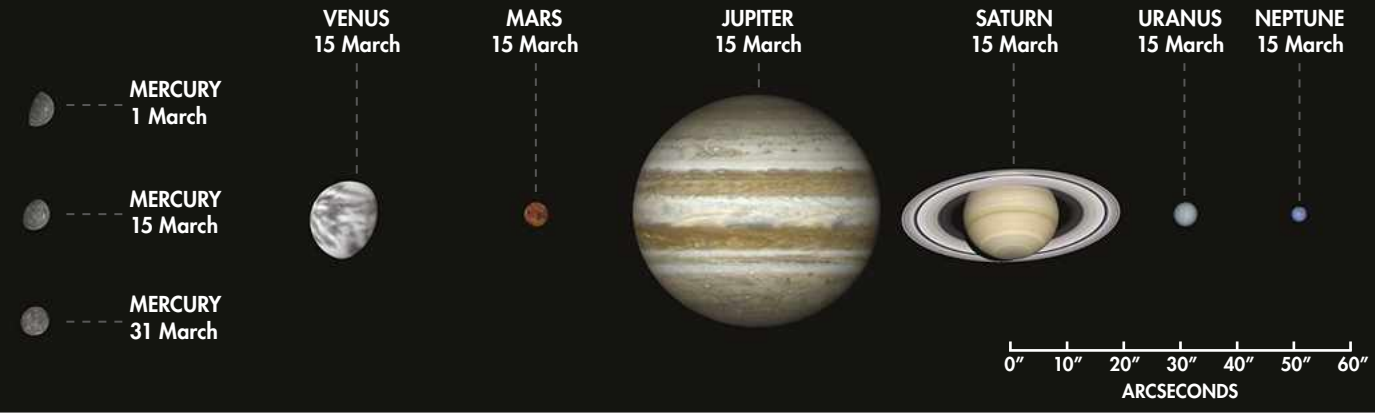
PETE LAWRENCE X 3

A small telescope is all that's required to see them. A low magnification of around 25-30x will show the planet to be elongated, while 50-60x will reveal that the elongations are indeed rings. Use as high a power as the conditions will stand.

A 65%-lit waning gibbous Moon lies close to Saturn on 12 March, the encounter being visible in the early hours before dawn. Saturn will be around 2° below and left of the Moon at this time. It is worth comparing the off-white, slightly yellowish hue of Saturn's mag. +0.7 dot with the mag. +1.0 red supergiant star Antares (Alpha (α) Scorpii) 8° below and left of the planet. Saturn will reach its highest point in the sky, due south, in total darkness at the end of the month.

THE PLANETS IN MARCH

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



JUPITER

BEST TIME IN MARCH:
1 March, 22:45 UT
ALTITUDE: 54°
LOCATION: Cancer
DIRECTION: South

Jupiter is currently in Cancer, not too far from the Beehive Cluster, M44. It is the best-placed of the planets, reaching its highest point at 22:40 UT at the start of March and 21:40 BST (20:40 UT) by the end – that's just as true darkness falls. It remains bright, appearing at mag. –2.5 on the 1st and only dimming to mag. –2.3 by month end. Even small scopes can show good detail, first and foremost the Southern and Northern Equatorial Belts; a 4-inch scope can show the famous Great Red Spot. A 93%-lit waxing gibbous Moon lies 6.5° to the southwest of Jupiter on the 3rd, and manages to make a second pass of the planet in a 75%-lit waxing gibbous phase on the 30th.

VENUS

BEST TIME IN MARCH:
31 March, 20:00 BST (19:00 UT)
ALTITUDE: 28°
LOCATION: Aries
DIRECTION: West

Well placed in the evening sky, over towards the west, Venus's intense mag. –3.9 dot should be easy to view 20-30 minutes after sunset. The planet itself sets three hours after the Sun at the start of March and three hours and 36 minutes at the end of month. On the 4th it passes close to and completely outshines Uranus – see page 51 – while on the evenings of the 22nd and 23rd it meets the waxing crescent Moon; the smallest separation of just 3.6° occurs on the 22nd. Through a telescope Venus's phase is decreasing and by the end of March it'll appear 78%-lit and 13 arcseconds across.

MARS

BEST TIME IN MARCH:
1 March, 18:45 UT
ALTITUDE: 14°
LOCATION: Pisces
DIRECTION: West

Mars is an evening twilight planet gradually slipping in towards the Sun's glare. It had a close encounter with Venus last month and during the early part of March it's interesting to watch how quickly they separate. Mars's disc is small at just 4 arcseconds across and too low after sunset for any serious viewing, but don't miss the encounter between it and dim Uranus on the 11th – see page 51. On 21 March, a thin, 2%-lit, waxing crescent Moon is 2.3° to the west of it.

MERCURY

BEST TIME IN MARCH:
1 March, 06:40 UT
ALTITUDE: 2° (low)
LOCATION: Capricornus
DIRECTION: Southeast

Although close to mag. 0.0, Mercury isn't particularly well placed this month. At the start of March it may just be seen close to the southeast horizon before sunrise; it remains potentially visible until the 7th but is lost soon after.

URANUS

BEST TIME IN MARCH:
1 March 19:15 UT
ALTITUDE: 15°
LOCATION: Pisces
DIRECTION: West

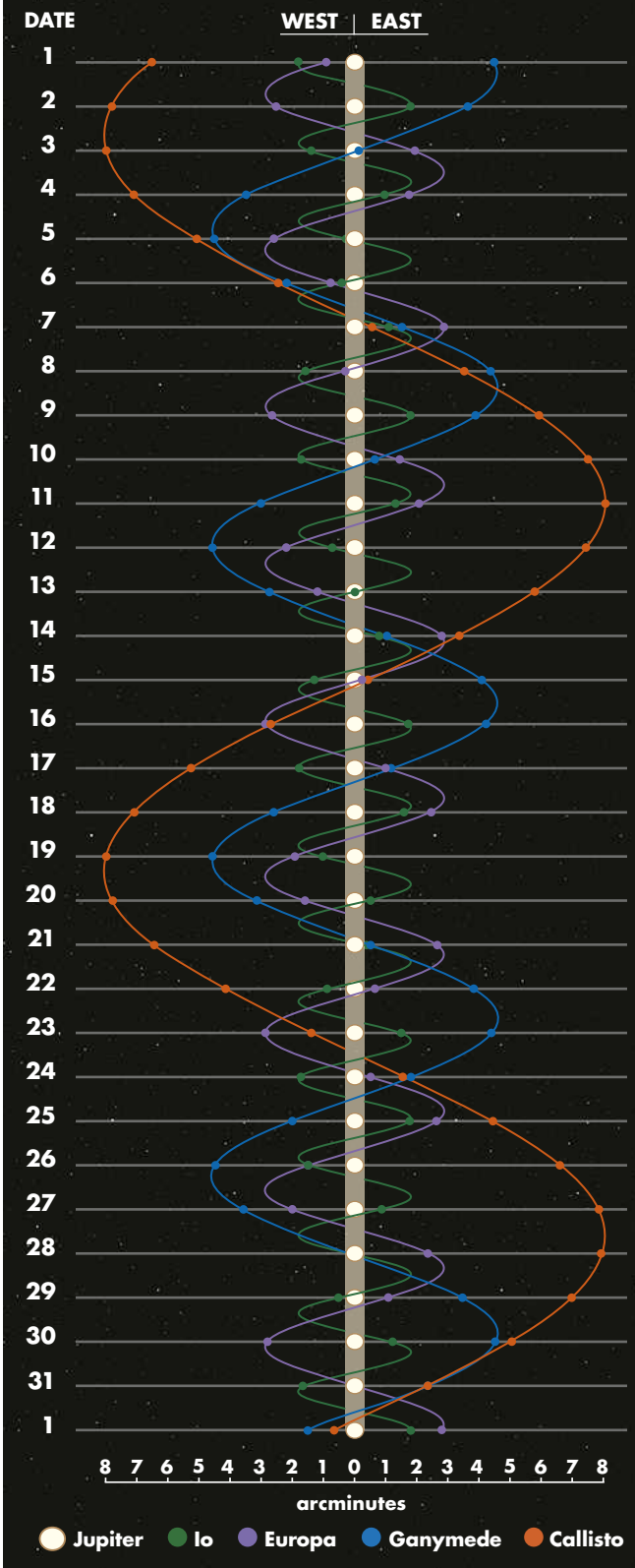
Uranus is altitude challenged this month and not a viable telescopic target. However, it does have two conjunctions: on the 4th the mag. +5.9 planet will be just 5 arcminutes from mag. –3.9 Venus, while on the 11th it will be 17 arcminutes from mag. +1.3 Mars – see page 51. Uranus will be lost from view at the end of the month.

NOT VISIBLE THIS MONTH
NEPTUNE

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools

JUPITER'S MOONS
March

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

- *Arcturus* — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cirdel — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- N E S W — COMPASS AND FIELD OF VIEW
- MILKY WAY

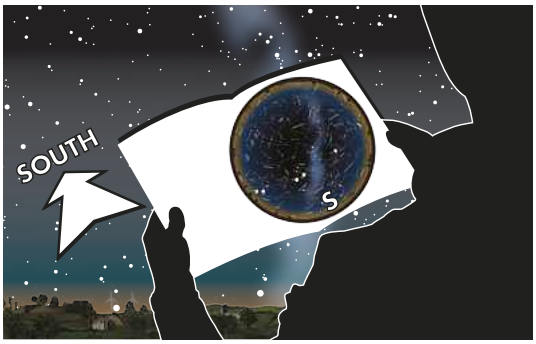
WHEN TO USE THIS CHART

1 MARCH AT 00:00 UT
15 MARCH AT 23:00 UT
31 MARCH AT 23:00 BST

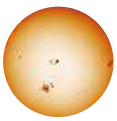
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



THE SUN IN MARCH*



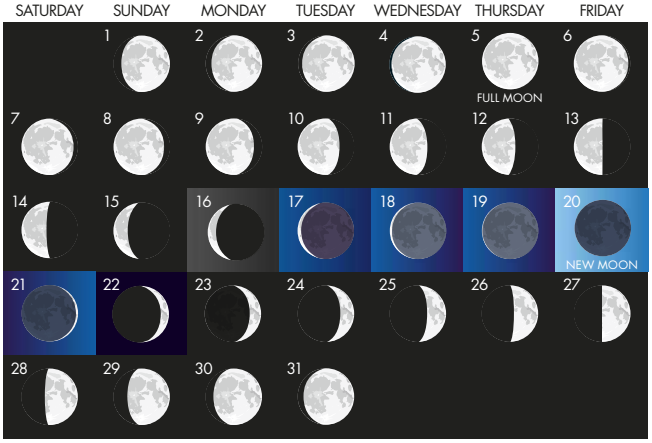
DATE	SUNRISE	SUNSET
1 Mar 2015	06:58 UT	17:47 UT
11 Mar 2015	06:35 UT	18:06 UT
21 Mar 2015	06:11 UT	18:24 UT
31 Mar 2015	06:46 BST	19:42 BST

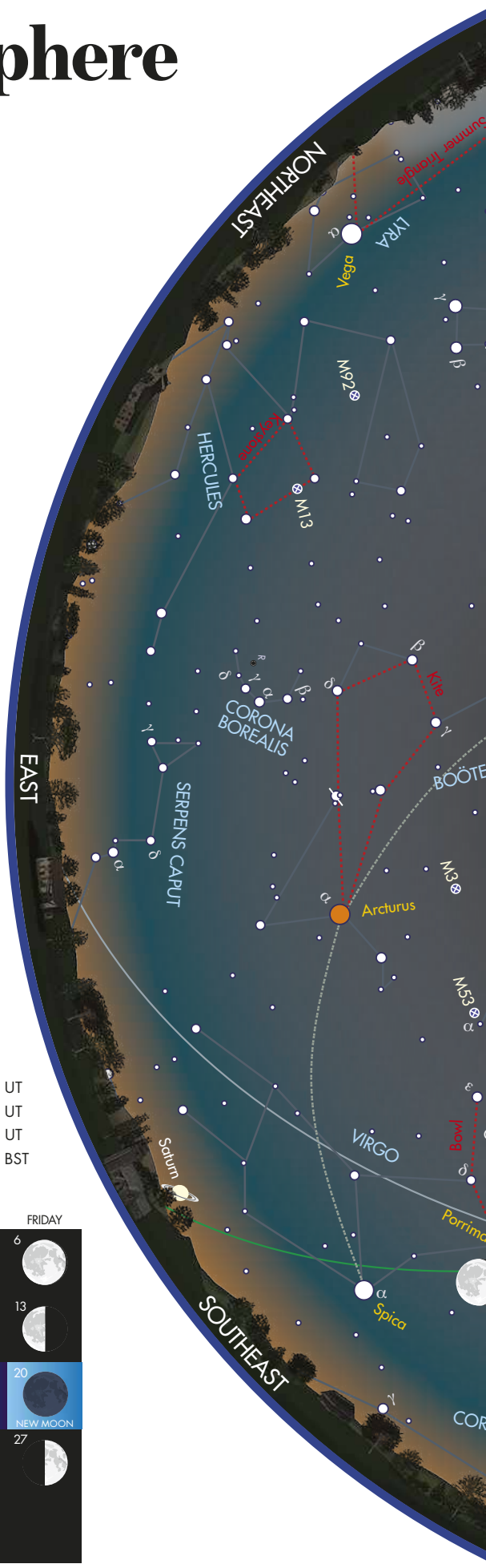
THE MOON IN MARCH*

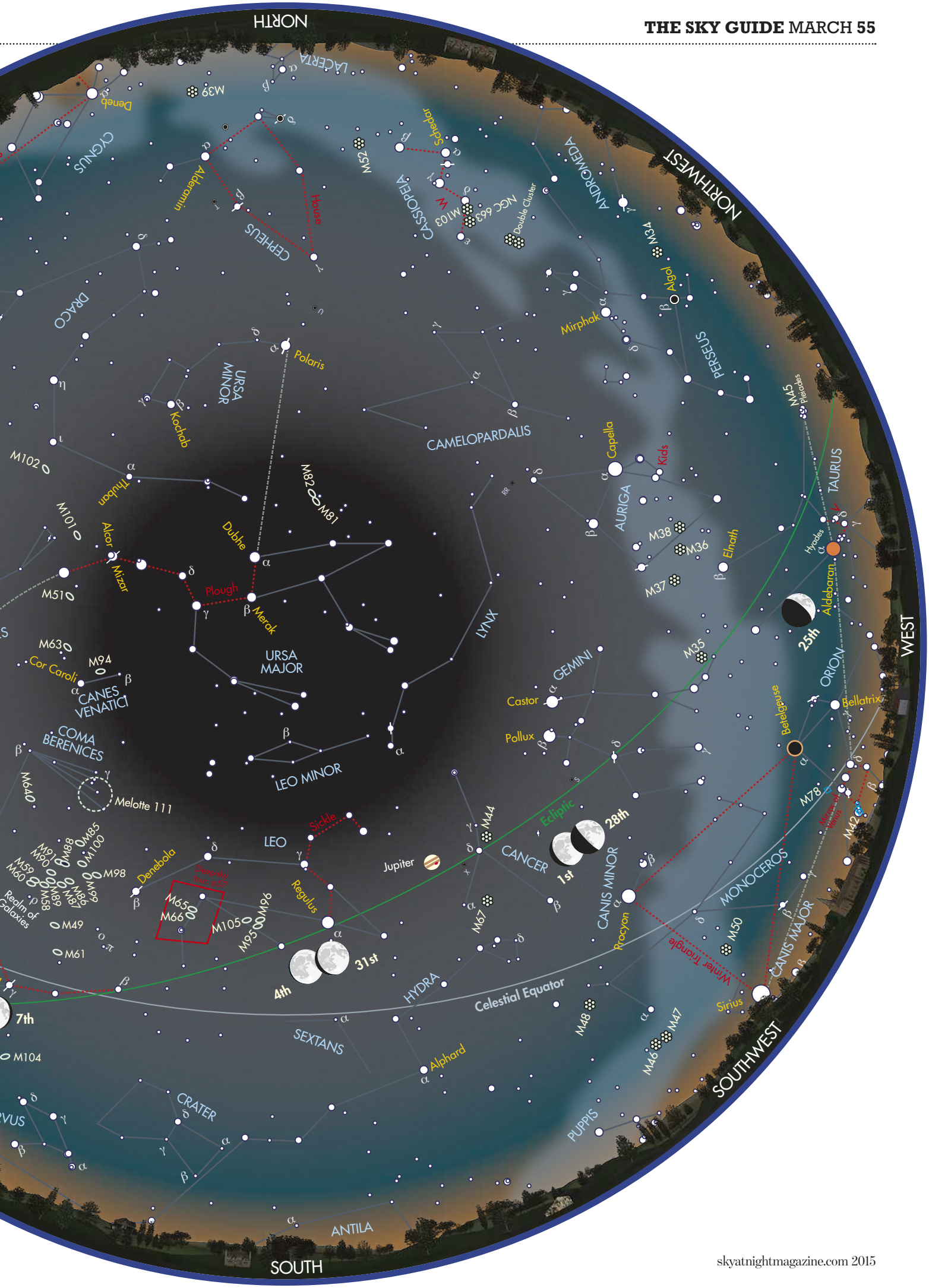
MOONRISE TIMES

1 Mar 2015, 13:46 UT	17 Mar 2015, 04:35 UT
5 Mar 2015, 17:57 UT	21 Mar 2015, 06:38 UT
9 Mar 2015, 22:14 UT	25 Mar 2015, 09:01 UT
13 Mar 2015, 01:24 UT	29 Mar 2015, 13:40 BST

*Times correct for the centre of the UK



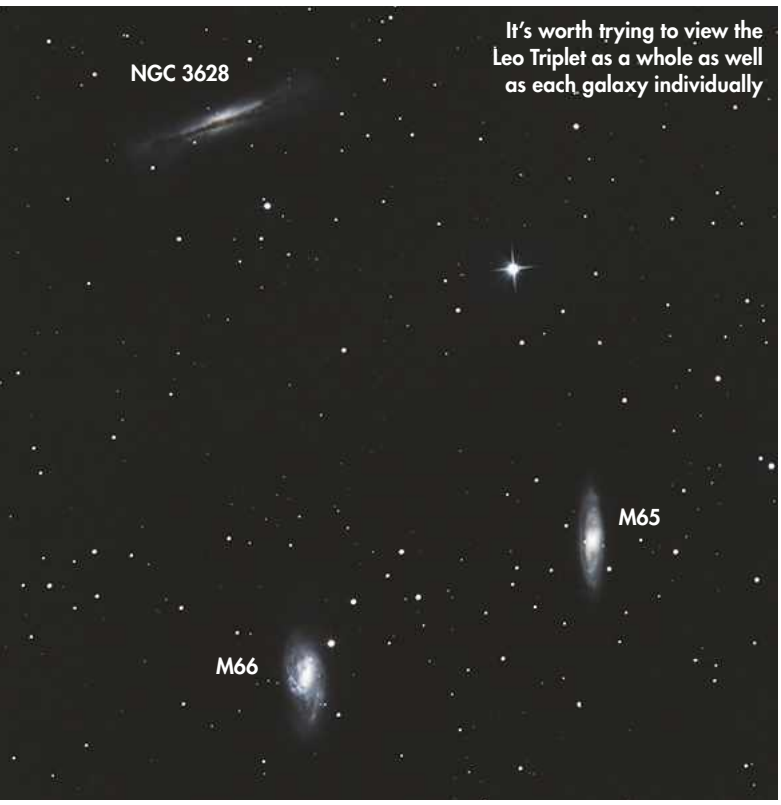



NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LACERTA
CYGNUS
Deneb
M39
Albireo
Alderamin
CEPHEUS
House
M52
Schedar
CASSIOPEIA
M103
NGC 663
Double Cluster
ANDROMEDA
M34
Algol
Mirphak
PERSEUS
DRACO
Polaris
URSA MINOR
Kochab
CAMELOPARDALIS
M5 Pleiades
Capella
Kids
AURIGA
TAURUS
M102
Thuban
M82
M81
M101
Alcor
Mizar
Dubhe
Plough
Merak
M51
M38
M36
Elnath
M37
Hyades
Aldebaran
25th
LYNX
M63
Cor Caroli
M94
CANES VENATICI
URSA MAJOR
GEMINI
Castor
Pollux
M35
ORION
Bellatrix
Betelgeuse
COMA BERENICES
M64
Melotte 111
LEO MINOR
Sickle
LEO
Denebola
Jupiter
Ecliptic
M44
28th
1st
CANCER
CANIS MINOR
Procyon
M78
M42
MONOCEROS
Realm of Galaxies
M98
M65
M66
M105
M95
M96
Regulus
M67
M49
M61
31st
4th
Winter Triangle
M50
CANIS MAJOR
Sirius
HYDRA
Celestial Equator
7th
M104
SEXTANS
Alphard
M48
M46
M47
CRATER
PUPPIS
ANTILA

Deep-sky tour

Explore the secrets of the famous Leo Triplet and the galaxies that surround it

☑ Tick the box when you've seen each one



1 NGC 3596

This month we're looking at galaxies in the southeast corner of Leo, the Lion. Start from mag. +3.3 Chort (Theta (θ) Leonis), which marks the top of Leo's rear leg. Locate the obvious mag. +7.4 star to the southeast of Chort in your finder, then move a similar distance due south to locate the area containing face-on spiral galaxy NGC 3596. This object first appears as a circular patch, approximately 2.5 arcminutes across. A 10-inch scope shows a gentle brightening towards the galaxy's centre. NGC 3596 is estimated to be an amazing 59 million lightyears distant. ☐ **SEEN IT**

2 M65

The most famous galaxies in Leo lie in a group known as the Leo Triplet, which is comprised of M65, M66 and NGC 3628. M65 lies almost halfway between Chort and mag. +4.0 Iota (ι) Leonis. The galaxy is mag. +10.2, making it an easy find in smaller scopes. It is a spiral with a similar inclination to the famous Andromeda Galaxy, M31. A 10-inch scope shows it to be 8x2 arcminutes in size, its brighter nucleus measuring 3x2 arcminutes. The galaxy's long axis is orientated north-south. East of the nucleus is a tricky dark lane in which there's a faint foreground star on the limit of visibility through larger apertures. ☐ **SEEN IT**

3 M66

M66 is an easy find once you've got M65 in the eyepiece because it lies just 20 arcminutes to the east and slightly south. It is a large spiral galaxy, marginally brighter than M65 at mag. +9.6, with a higher tilt angle towards us and a less symmetrical appearance. Again, the orientation of the long axis of the galaxy is north-south, but in this case the core is less obvious. Larger instruments show a mottled region to the northeast caused by various star-forming blotches in one of the spiral arms. A 10th-magnitude star can be seen just to the northwest. ☐ **SEEN IT**

4 NGC 3628

NGC 3628 is the faintest member of the Leo Triplet but also the most distinctive. It lies 0.6° due north of M66. A small scope reveals it as an elliptical hazy patch, while a 10-inch scope shows it to be approximately 10x1 arcminutes in size, orientated east-west and rather rectangular in appearance. The bright core measures 3x0.75 arcminutes. There's an asymmetry here, as the faint western extension appears larger than that seen to the east. A dark dust lane cuts through the centre of the galaxy – it starts to become obvious in apertures over 8 inches. Before you move on, consider switching to a lower power eyepiece – it is worth it to try and get all three members of the Leo Triplet into the view at once. ☐ **SEEN IT**

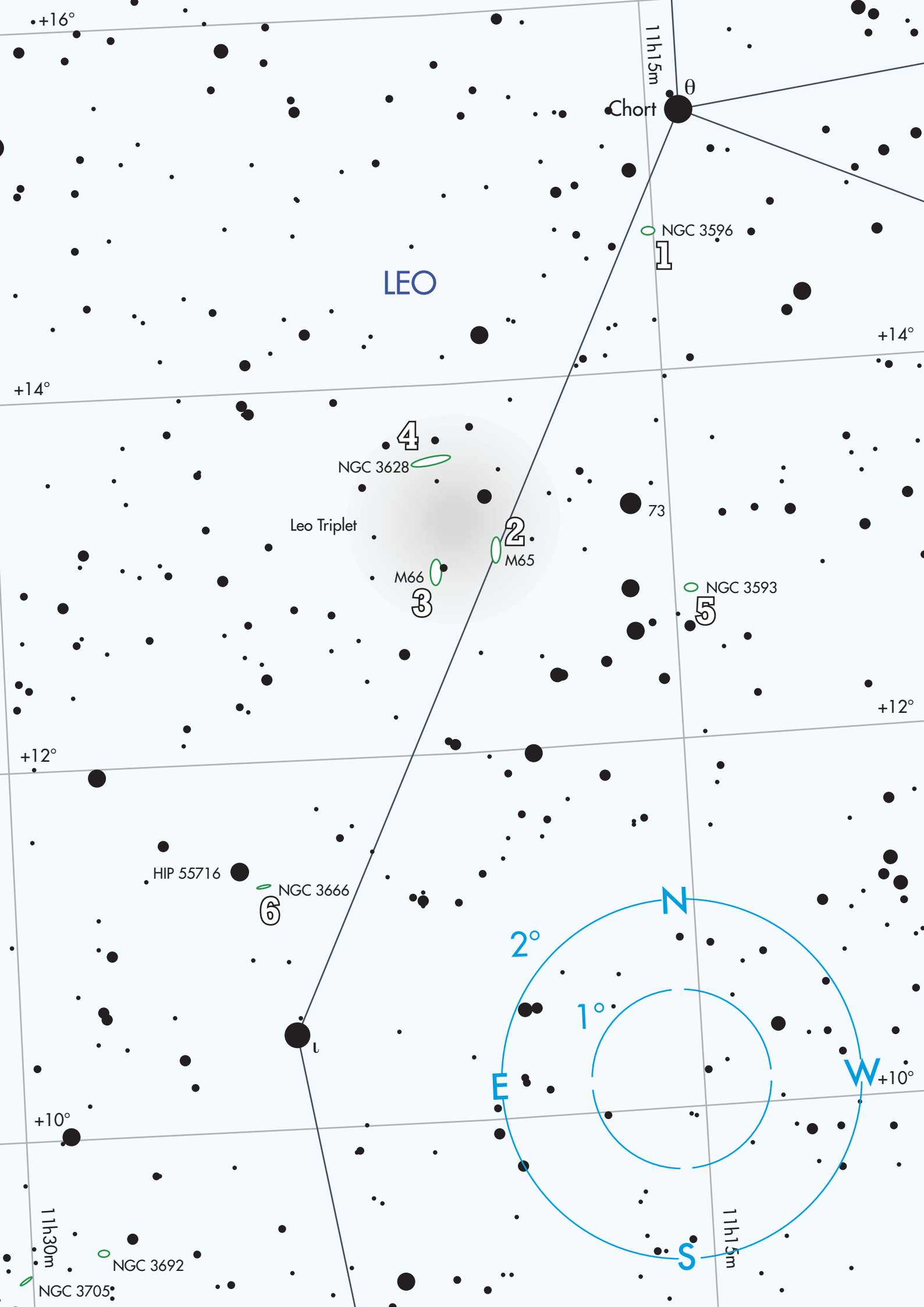
5 NGC 3593

NGC 3593 lies fractionally more than 1° to the west and slightly south of M65. It is relatively faint at mag. +11.0 and fairly small. In a 10-inch telescope, NGC 3593 appears as an east-west elongated smudge measuring 3x2 arcminutes. This is a starburst galaxy, where stars are being formed at a high rate. It's also interesting in that it contains two counter-rotating populations of stars, something believed to occur when a galaxy gravitationally absorbs material from another source. NGC 3593 is 20.5 million lightyears away and is regarded as a type 'SA(s)0/a': a lenticular galaxy of the spiral type. ☐ **SEEN IT**

6 NGC 3666

The joint in Leo's rear leg is marked by 4th-magnitude Iota (ι) Leonis, which lies 2° and 49 arcminutes south-southeast of M65. Look 1° north of this star to reach mag. +5.8 star HIP 55716. Our final galaxy, NGC 3666, lies 9 arcminutes southwest of here. At mag. +12.7, this is the faintest object in this month's target list and in an 8-inch scope it looks like an elongated smudge of quite even brightness. Averted vision should reveal a faint, star-like core that shines away at around mag. +14.5. The proximity of HIP 55716 can be a problem here, so arrange for it to be just outside the field of view. ☐ **SEEN IT**

CHART: PETE LAWRENCE; PHOTO: ISTOCK


+16°
11h15m
θ
Chort
NGC 3596
1
LEO
+14°
+14°
4
NGC 3628
73
Leo Triplet
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3
NGC 3593
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+12°
+12°
HIP 55716
NGC 3666
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+10°
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11h15m
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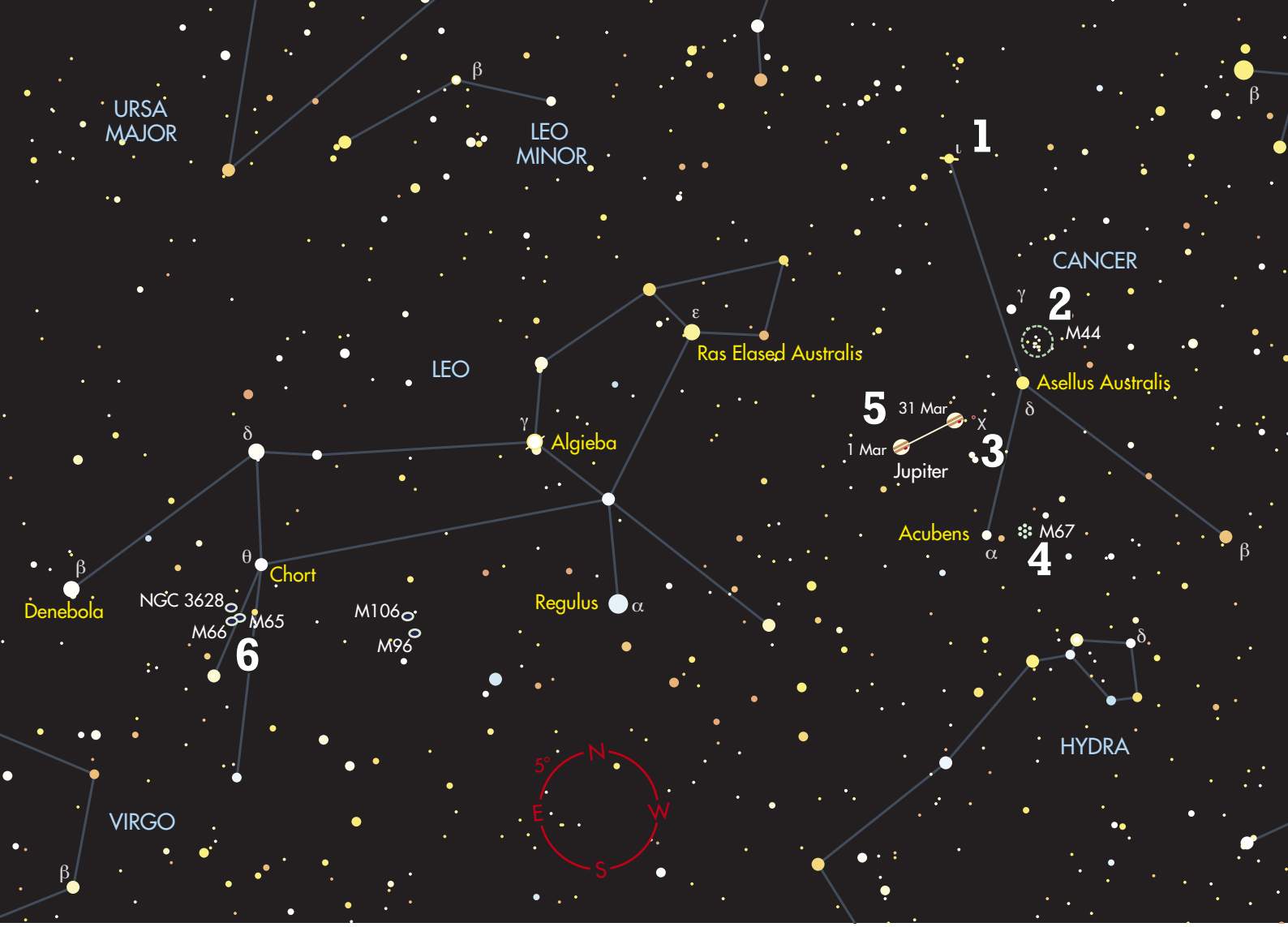
NGC 3692
NGC 3705



With **Stephen Tonkin**

Binocular tour

Savour a buzzing Beehive and a cluster very similar to the one that birthed our Sun

☑ Tick the box when you've seen each one

1 IOTA CANCRI

10x 50 Iota (ι) Cancri is a double star that lies halfway between mag. +1.9 Castor (Alpha (α) Geminorum) and the star at the end of the Sickle asterism, mag. +3.0 Ras Elased Australis (Epsilon (ε) Leonis). The components of Iota Cancri shine at mag. +4.0 and +6.0 respectively. Only 30 arcseconds separate them, making them a good test of 10x50 binoculars which, ideally, should be mounted. If you have no mount, this is your incentive to try out some of the steadying techniques suggested in this month's *How to* on page 82. ☐ **SEEN IT**

2 THE BEEHIVE CLUSTER

10x 50 M44, commonly known as the Beehive Cluster, is visible to the naked eye as a large (1.5°) misty patch just north-northwest of mag. +3.9 Asellus Australis (Delta (δ) Cancri). At 577 lightyears away it is one of the nearest open clusters and it contains over 1,000 stars, more than any other nearby. It appears brighter in the middle due to mass segregation, a phenomenon in which interactions between heavy and light stars cause the light ones to move faster, so they end up a greater distance from the centre of the cluster. ☐ **SEEN IT**

3 X CANCRI

10x 50 Just over 2° east of Asellus Australis is a 1° line of three 6th- and 7th-magnitude stars. The middle of these is X Cancri, a semiregular variable carbon star with a period of 180 days and a range of mag. +5.7 to +6.9. Semiregulars are giant or supergiant stars whose main period is overlain by irregular changes in magnitude. This one is one of the few stars to have had its apparent diameter measured by lunar occultation, approximately 8.5 milliarcseconds. ☐ **SEEN IT**

4 M67

10x 50 Our next cluster is just under 2° west of mag. +4.3 Acubens (Alpha (α) Cancri). M67 is mag. +6.1 and has the same apparent diameter as M35 in Gemini. It appears as a misty patch with five or so stars resolved in 10x50 binoculars. Like M44, it is brighter in the middle due to mass segregation. Our Sun was born in a cluster just like M67 at approximately the same time that M67 was born. At a distance of 2,700 lightyears, M67 is relatively close and contains around a hundred Sun-like stars, for which reason it is one of the most studied clusters. ☐ **SEEN IT**

5 JUPITER

10x 50 Jupiter is the very bright object about 6° east of M44. Although you won't see any surface detail in small binoculars, it is surprisingly easy to observe its Galilean moons. The main problem is glare from the planet itself, so make sure your binoculars are clean, focused and preferably mounted. Start by using the chart on page 53 to see when Callisto is at greatest elongation (apparent distance from the planet), the time it is easiest to observe. Once you have had some practice, try to see how close to the planet you can distinguish a moon. ☐ **SEEN IT**

6 THE LEO TRIPLET

15x 70 Wait until Leo is high in the southern sky to look for our final objects: galaxies M65, M66 and NGC 3628, collectively known as the Leo Triplet. They are a challenge in anything other than a dark transparent sky. If you put mag. +3.3 Chort (Theta (θ) Leonis) just outside the northwest of the field of view of 15x70s, the galaxies will be in the centre. You may need averted vision at first but they become easier; in the end you should only need averted vision to discern the unusual shape of NGC 3628. ☐ **SEEN IT**

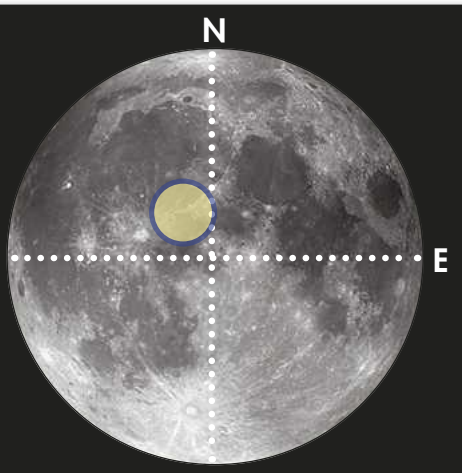
CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

The Sinus Aestuum

STATISTICS

TYPE: Lunar bay
SIZE: 260x260km
AGE: 3.9-4.6 billion years
LOCATION: Latitude 12.0°N, longitude 8.3°W
BEST TIME TO OBSERVE: Last quarter or one day after first quarter (12-13 March and 28-29 March)
MINIMUM EQUIPMENT: 10x binoculars



THE SINUS AESTUUM, or Bay of Billows, is an area of flat lava that sits to the southeast of crater Eratosthenes (60km wide) and, centre-to-centre, 370km east of the impressive ray crater Copernicus (93km). One of the most notable features of the Sinus Aestuum is the pattern of light and dark material that crosses its surface with an east-west orientation. The floor of the bay is naturally dark, the lighter pattern being the result of material thrown out when crater Copernicus was formed. Under direct illumination the rays crossing Aestuum's floor are very evident.

The eastern border of the bay is marked by a change in surface texture from smooth lava to rough terrain. This transition region divides the Sinus Aestuum from the Mare Vaporum to the east. The north and northeast borders are marked by the impressive Lunar Apennine mountain range. The peak that sits in the northeast 'corner' of the bay is the 3.5km-high Mons Wolff.

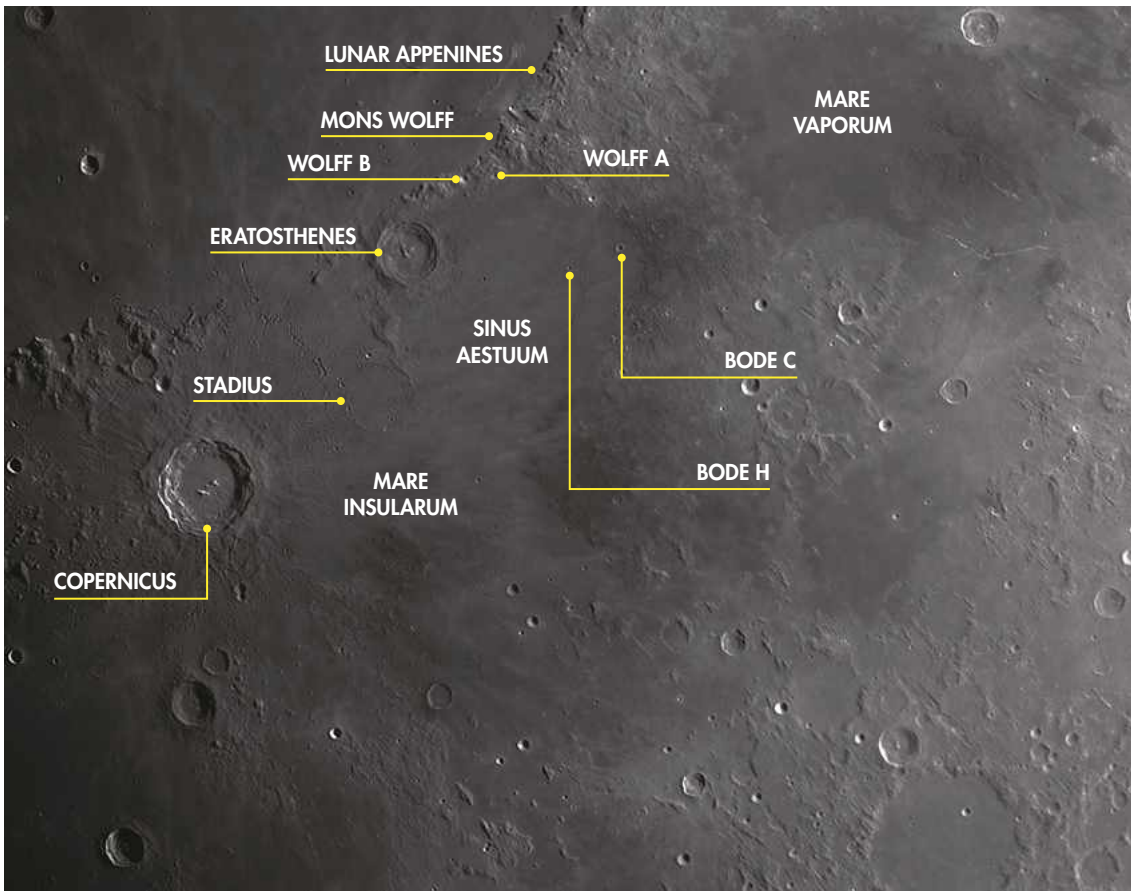
The Apennines peter out to the west of Mons Wolff as they head towards Eratosthenes. An 8km crater known as Wolff B sits at the mid-point along this short portion of the Apennine range, with even smaller Wolff A (6km) sitting 30km to the east.

Upon reaching Eratosthenes, the Apennine mountain range comes to a stop with an elevated outcrop hanging southwest of the crater. Eratosthenes itself is a beautiful crater, with a sharp and internally terraced rim framing a prominent central mountain complex. The influence of the crater can be seen as an undulating texture heading into the Sinus Aestuum, like an elevated, 25km-wide collar around the rim.

The mid-point of a line drawn between the centres of Copernicus and Eratosthenes leads the eye to – for want of a better term – a 'splatter zone' where chains of craterlets presumably from the Copernican impact can be seen. Southeast of the mid-point of this line and abutting the western edge of Aestuum is the ghost crater Stadius (70km), which comes to life when the terminator is near. Under oblique illumination its circular outline becomes quite noticeable, but under higher illumination it becomes quite hard to locate and looks like it has been filled in with lava and then levelled off with a trowel.

There are features to be seen on the floor of Sinus Aestuum, despite its flat appearance. When the terminator lies near, a wrinkle ridge can be seen running parallel with the edge of the bay in the southeast. The largest crater in the bay is Bode C (7km), which should be visible in a 4-inch scope. Once located, move your gaze 55km (that's about the diameter of Eratosthenes) to the west to locate Bode H (4km). At this size, things start to get a bit harder; you'll need an 8-inch scope to see this particular craterlet.

"Abutting ghost crater Stadius comes to life when the terminator is near"



Though the floor of the Sinus Aestuum appears generally flat, look closely and you will find hidden detail

Astrophotography

Photographing the partial eclipse of the Sun

RECOMMENDED EQUIPMENT

DSLR camera, remote shutter release, driven tracking mount and a lens or telescope with a focal length of 300-1,200mm.

This partial eclipse is going to be a big one – appearing at least 80 per cent from all over the UK

THE LAST NOTABLE solar eclipse visible from the UK occurred on 4 January 2011, when a decent 75 per cent partial eclipse was seen under difficult conditions at sunrise. Prior to this, on 1 August 2008, the north of Scotland got a 40 per cent partial eclipse, while southwest England saw a 20 per cent eclipse. This month we get an altogether more impressive prospect, and we're going to look at how to capture it on camera here.

On 20 March a total eclipse will be visible along a track running approximately 240km northwest of northwest Scotland. The land closest to the track will see the largest partial eclipse. From the Isle of Lewis in the Outer Hebrides, 97.8 per cent of the Sun's disc will be covered by the Moon. The smallest eclipse will be seen from the southeast, where coverage will be a still impressive 82.7 per cent.

Visually observing the eclipse requires the use of a solar safety filter to protect your eyes (see page 50) and cameras are no different. A white light filter made from solar safety film is ideal. An A4 sheet of this material typically costs less than £20 and is easy to turn into a fitted filter to protect your equipment.

Covering the front of a lens will allow you to point your camera directly at the Sun in safety. A telescope can also be used as the lens for a DSLR if you have a suitable adaptor – and here too solar safety film is needed to cover the entire front aperture of the telescope. If using a telescope, it's important to make sure any finders are capped, filtered or even removed before pointing the main scope at the Sun.

If your telescope has a front opening that is too large to cover with a sheet of A4 filter material, you have two options: either buy a larger sheet of film or create a mask to reduce your scope's aperture. The popular Baader AstroSolar Safety Film can be obtained in rolls measuring 1x0.5m for around £60. Alternatively, a stiff card covering applied to the entire open aperture with a circular hole cut in it can be used to reduce the area that needs filtering. For reflectors and other telescopes that have a central obstruction. The hole needs to be made off to one side so it extends from the edge of the telescope tube to the edge of the obstruction.

Once you're filtered, the rest is relatively easy. The steps on the opposite page describe how to get an image or sequence of images of the Sun during the partial eclipse. If you don't have a sophisticated camera, then the technique of filtering can still work as long as you can position the Sun's filtered image in such a way that the camera can get a lock on it to enable its automatic functions. This will work with point and shoot cameras as well as mobile phone cameras.

Alternatively, a 2-3mm 'pinhole' in a piece of card can be used to project an image of the eclipsed Sun onto the ground or a wall. Multiple holes, such as those in a colander, will produce multiple eclipse images, which are also fun to photograph (see page 36).

KEY TECHNIQUE

KEEP AN EYE ON YOUR FOCUS

One of the easiest mistakes to make when imaging an eclipse is poor focus. What may look sharp on a camera's preview screen can, when viewed full size, look a bit soft and mushy. Accurately focusing in the first place will overcome this, but it's still possible for focusers to slip or expand throughout a long session. A handy tip here is to regularly refocus. That way, even if some images do turn out slightly soft, you improve the probability of getting some that are good and sharp.

Send your image to: hotshots@skyatnightmagazine.com

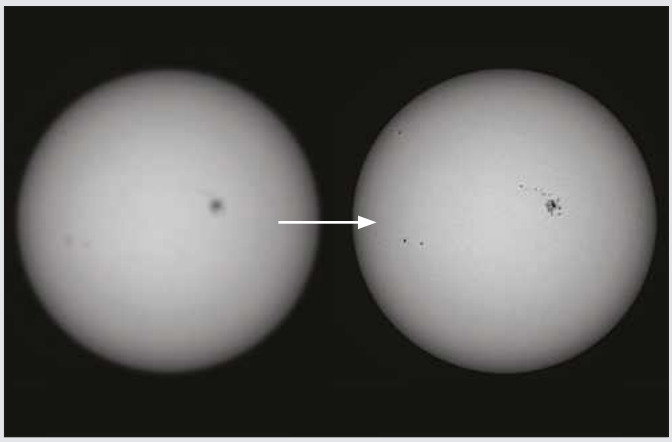
ALL PICTURES: PETE LAWRENCE

STEP-BY-STEP GUIDE

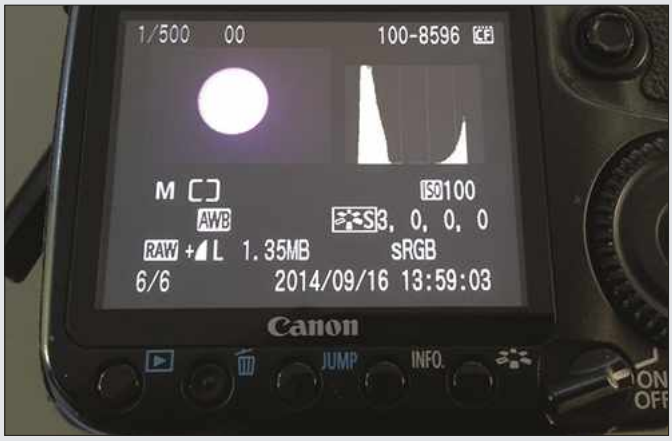
STEP 1 The Sun's disc isn't actually that big in the sky, measuring about 0.5° across. Consequently, you need a lens or scope focal length of 300-1,200mm to get an image scale that will show the disc and eclipse stages clearly. You'll find it easier to mount scopes close to the upper limit of this focal length range on a driven tracking mount.

STEP 2 The most common type of white light solar filter uses AstroSolar Safety Film. It's sold in A4 sheets, so you need to do a bit of DIY to turn it into a filter. This is easy to do, simply requiring you to create a slip-on tube from cardboard, one end of which is covered with the filter material. Find out more at www.skyatnightmagazine.com/solarfilter.

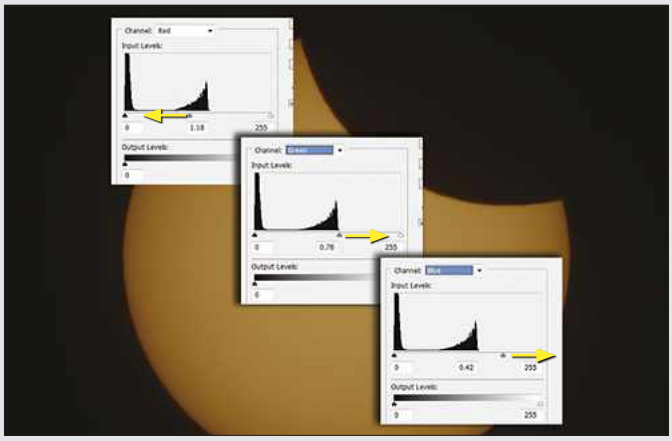
STEP 3 Set up your telescope making sure it is pointing away from the Sun. Check the filter has no holes or tears; if there are none, fit it over the telescope's aperture. Cap, remove or filter the finder. Turn the scope towards the Sun. Use the changing shape of the telescope's shadow on the ground or on a wall to aim directly at our parent star.



STEP 4 Fit your camera and use it to fine tune the position of the Sun. Focus as accurately as possible; a black cloth over your head and the back of the scope is the best way to do this. Use the Sun's edge or a well-defined sunspot if there's one present. A DSLR with Live View is ideal for this. Set the ISO to 100.



STEP 5 Use a remote shutter release to avoid wobbling the camera. The best exposure depends on your setup, but 1/500s is a good starting point. Check the image histogram, the main peak of which should fit between both ends of the graph. Increase the exposure if the image is too dark or shorten it if the image is too light.



STEP 6 Assuming you want to record a sequence, a five- or 10-minute gap between shots is ideal. The Sun's disc will be grey-blue in the your images; to create a more pleasing yellow, convert each to black and white and adjust the individual RGB midtones. Typically R towards the black end, G slightly towards white and B even further towards white.

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MESSENGER'S LAST DISPATCH

As NASA's Messenger mission comes to an end, **Will Gater** looks at what the spacecraft has told us about the scorched inner planet Mercury

NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/CARNEGIE INSTITUTION OF WASHINGTON X 2

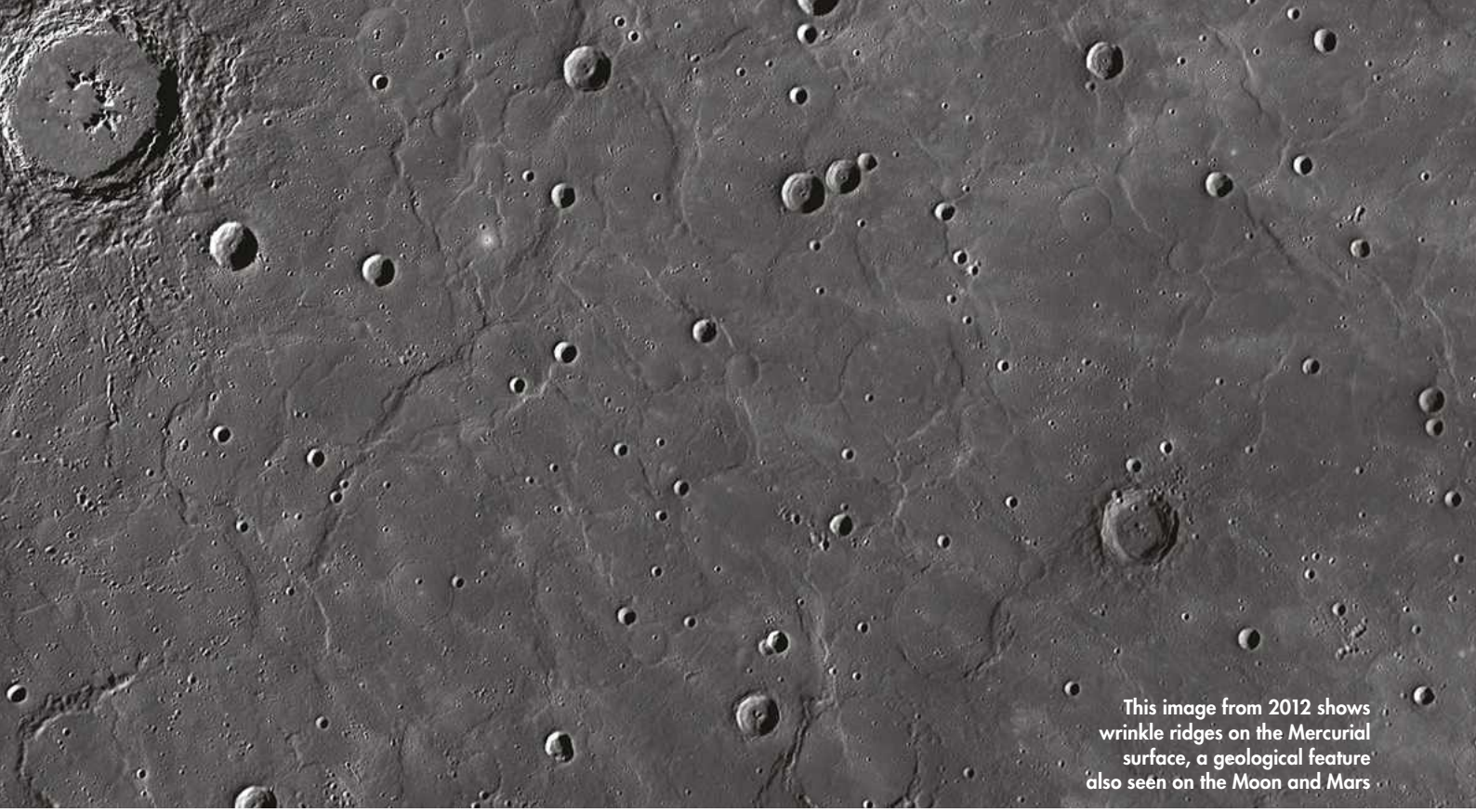
On the face of it, the picture taken by NASA's Messenger probe on 6 May 2010 could be one of the most bland images ever returned from space: a simple black square flecked with grains of white. In one corner two tiny little orbs, one noticeably larger than the other, appeared to glow against the dark background.

Amid the multitude of vibrant celestial images released by space agencies every month, you could be forgiven for overlooking this particular missive from humankind's great spacefaring fleet. In truth, while it may have been monochrome, Messenger's view that day was anything but mundane. In many ways it was a picture that summed up just how far the spacecraft had travelled since its night launch from the Florida coast in 2004, and today stands for everything this mission has achieved now that it is nearing its final chapter. Far from being distant alien worlds, the two orbs Messenger had photographed were Earth and the Moon.

The spacecraft had been commanded to turn its cameras in the direction of home, some 183 million km away. Yet even as Messenger imaged Earth from afar, it was the probe's final destination – the cratered and sun-scorched world Mercury – that the mission's scientists had their own eyes on.

Messenger had made three brief flybys of Mercury prior to capturing its evocative portrait of Earth and the Moon. For Louise Prockter, working on the spacecraft's Mercury Dual Imaging System (MDIS), that first flyby brought the most memorable moment of the whole mission.

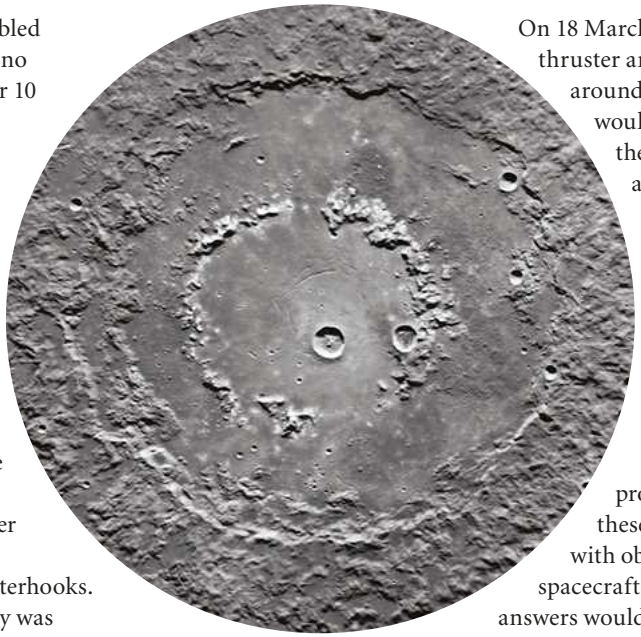
"Many of the team were clustered around a computer in our operations centre waiting for the first image of Mercury to be sent down from the spacecraft," she recalls today. "At that time, I was the instrument lead for MDIS and had spent most of the previous year planning the flyby observations, so I was quite anxious as you can imagine." ▸



This image from 2012 shows wrinkle ridges on the Mercurial surface, a geological feature also seen on the Moon and Mars

► Of particular interest to the assembled scientists was a side of Mercury that no one had seen before. NASA's Mariner 10 spacecraft had taken photographs of the planet when it sailed past in 1974 and 1975, but its cameras could see nothing of vast swathes of the surface. Now the researchers waiting on Earth faced a nerve-wracking wait for Messenger to reveal all.

"We had planned the downlink stream so that the first image received on the ground would be of the previously unseen hemisphere of Mercury," says Prockter. "For various reasons, we had to wait longer than expected for the data to be sent back to Earth and we were all on tenterhooks. Suddenly, a perfect image of Mercury was there, on the screen, of the hemisphere never before seen from a spacecraft. Cheers went up, people were hugging each other and a few tears were shed. We realised we had been successful – Messenger had imaged Mercury and we had just made history."



▲ Messenger's images of the hemisphere not seen by Mariner 10 revealed wonders; this one shows twin-ringed crater Raditladi

An eager emissary

As well as its camera system, Messenger carried several other instruments: spectrometers to study the chemical make-up of the planet, a laser altimeter for mapping the topography and a device capable of studying Mercury's magnetic field. From the first encounter the probe returned valuable scientific data. But the mission's aim wasn't merely to get passing glimpses of the world it had come to study. Messenger would do something that no other spacecraft had ever done – go into orbit around the planet.

On 18 March 2011 Messenger fired its thruster and settled into its first lap around Mercury. From then on it would be the team's orbital eyes on the planet – scanning, scrutinising and attempting to answer some of the big questions scientists had about the little rocky world.

That covered everything from the planet's geological history and interior to its formation and composition, says Messenger's principal investigator Sean Solomon.

"When the mission was proposed we argued that each of these questions could be answered with observations made by an orbiting spacecraft," he says. "Moreover, those answers would improve our understanding of the inner planets more generally."

Today, looking back on Messenger's time at Mercury, Solomon says our view of the planet has changed dramatically. "All aspects of the planet have been characterised globally for the first

► Ancient volcanoes were quickly discovered; this vent, surrounded by a bright pyroclastic deposit, is located close to the Rachmaninoff basin

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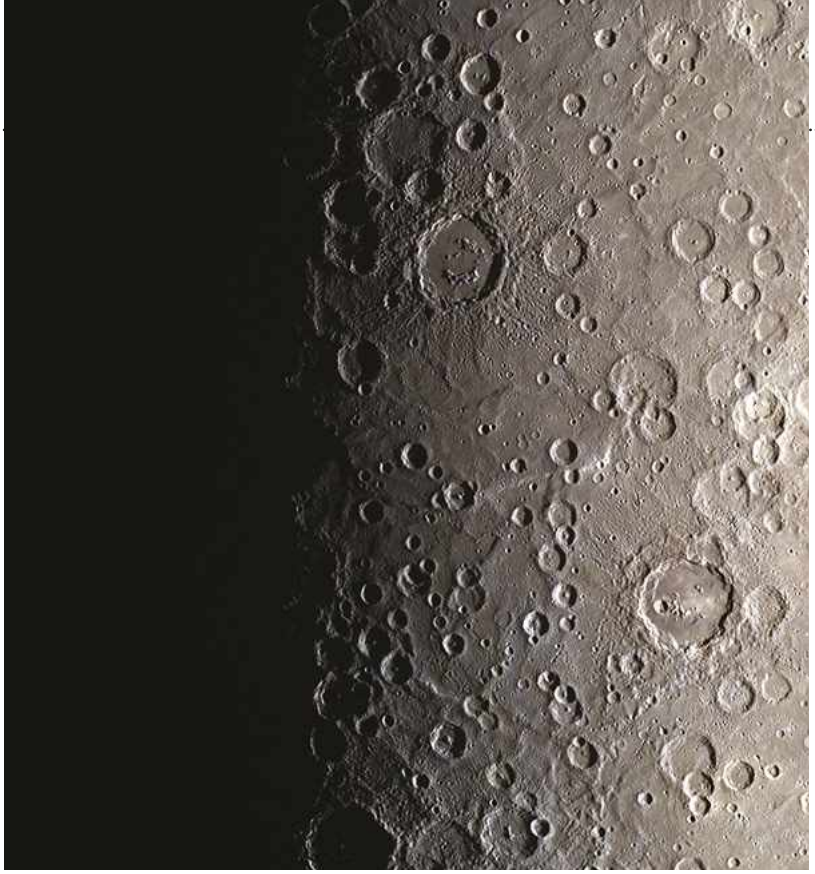
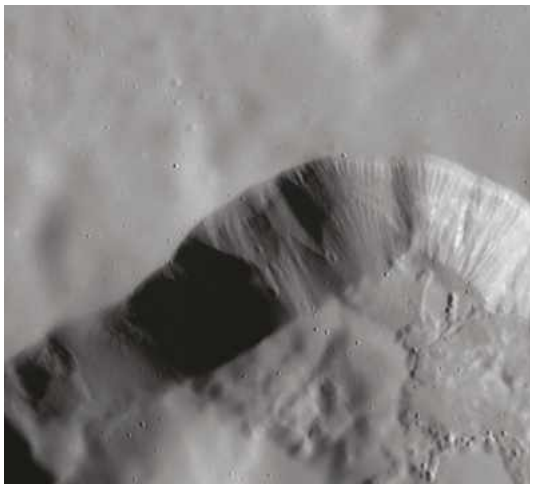


▲ Day turns to night; one solar day on Mercury lasts for 176 Earth days



◄ The smooth texture surrounding this volcanic vent is a blanket of lava ejected during a pyroclastic eruption

time," he says. "We are quite literally rewriting the textbook on the innermost planet."

Of all the scientific data returned by Messenger it is the thousands of images captured by its cameras that are perhaps the most conspicuous. To date the probe has sent back more than 250,000 high-resolution pictures of Mercury and its cratered landscapes, enabling scientists to comprehensively map the planet's surface.

"The vast majority of images have only had a cursory analysis," says Prockter. "It will be years, if not decades, before they have all been thoroughly analysed – we have a lot of image data!"

Even so, Messenger's images have already shed considerable light on the planet's volcanic history, an aspect of Mercury's past that's fascinated scientists for decades. Superficially Mercury resembles our own Moon: scarred and cratered by aeons of impacts, barren and – to an extent – monochrome. But early pictures of the planet's surface also showed another, more enigmatic, type of terrain.

"The flybys by Mariner 10 in the 1970s raised the tantalising prospect that at least some portion of Mercury's surface was volcanic because it returned images of relatively smooth areas on the planet's surface," says Paul Byrne of the Lunar and Planetary Institute in Houston, Texas.

"One of the easiest ways to make smooth, lightly cratered terrain is to resurface the landscape with lava. However, around this time scientists discovered that some smooth portions of terrain on the Moon were the result of fluidised material ejected from large impacts blanketing the area, and they argued that same process formed the smooth patches on Mercury," he adds. "So, although there was circumstantial evidence of expansive resurfacing of Mercury by lava, the question of whether volcanism had really operated on the innermost planet remained open."

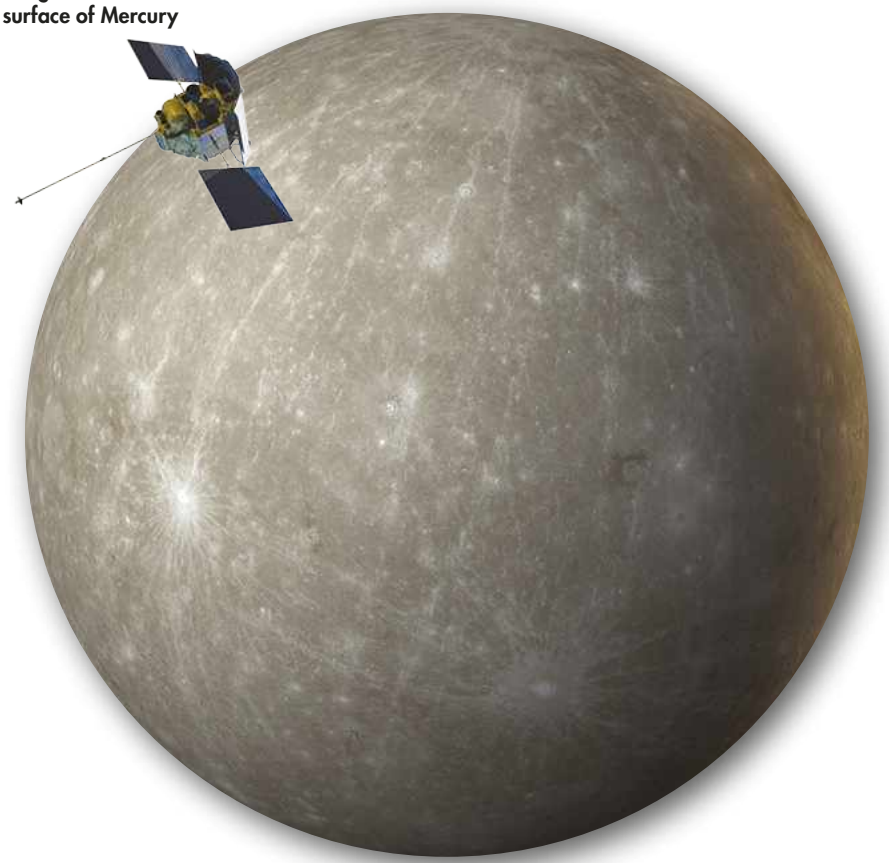
That all changed with the arrival of Messenger at Mercury. It didn't take long for the spacecraft's cameras and instruments to uncover evidence of the planet's volcanic past.

The scars of volcanism

"We see lava flows inundating impact craters and other pre-existing features, spectral differences between smooth areas and surrounding older terrain, and nearby the broad lava plains, landforms we associate with volcanic processes on other planets," says Byrne. "We also now know that at least a couple of hundred million years of Mercury's oldest crust is missing, an observation best explained by that material having been resurfaced by voluminous lava flows."

Messenger has even been able to reveal that the radius of the planet shrank by a staggering 7km as it cooled after its formation. But it's at ►

▼ Messenger has now imaged the entire surface of Mercury

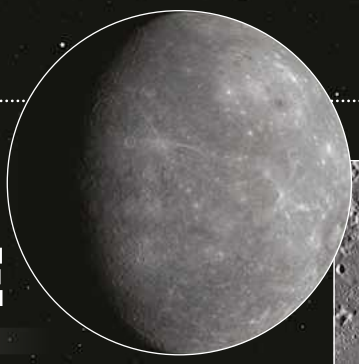


MESSENGER MISSION TIMELINE

▼ 3 August 2004
Launch day for Messenger. The spacecraft successfully takes flight with a night launch from Cape Canaveral in Florida, US.

▲ 2 August 2005
Almost exactly a year after launch Messenger performs a flyby of Earth, using our planet to propel it back around the Sun and onward to the inner Solar System.

2006 & 2007 ▶
On its way to Mercury the spacecraft makes two passes of enigmatic Venus. As it leaves in June 2007, it takes images of the cloudy planet's ever-shrinking crescent.



▲ 14 January 2008
Messenger performs its first flyby of tiny Mercury, sending precious imagery and science data back to mission controllers on Earth.

▲ 6 October 2008
The spacecraft makes its second flyby of Mercury at a distance of 200km. It would fly past the planet one last time in September 2009.

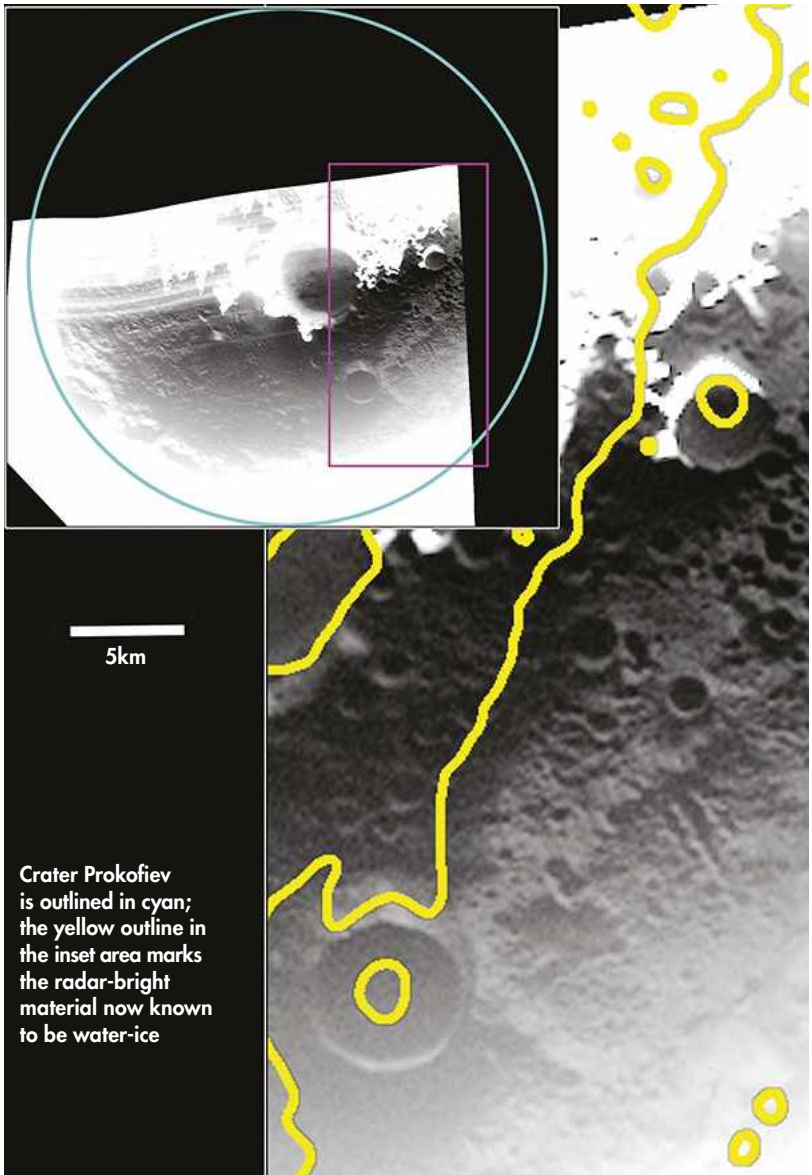
▸ Mercury's poles that the spacecraft has made some of its most enthralling discoveries.

"In the early 1990s, radar images revealed that Mercury's north and south poles hosted radar-bright material," says Carolyn Ernst, deputy instrument scientist for Messenger's Mercury Laser Altimeter. "The radar properties of these areas are consistent with those of the icy moons of Jupiter and the polar caps on Mars, suggesting that these radar-bright features on Mercury might also be water-ice."

The mystery only deepened when it was later found that some radar-bright spots were located inside craters. "This supported the hypothesis of water-ice within permanently shadowed craters, but it could not be definitively confirmed," says Ernst. The Messenger scientists hoped their mission could provide some answers.

From orbit, Messenger's Neutron Spectrometer instrument was able to detect accumulations of hydrogen near to the north pole – evidence, the team argued, that there was water-ice there – while observations by the Mercury Laser Altimeter showed where the permanent shadows were and allowed scientists to work out the temperatures of the surface and subsurface.

"The radar-bright areas all coincided with areas modelled to be stable for either surface or subsurface ice," says Ernst. With evidence mounting that Mercury did indeed harbour water-ice in its north polar region, Messenger's camera system team made a startling discovery. By taking advantage of the faint light scattered around inside certain shadowed craters they were able to photograph the hidden crater floors. Notably within

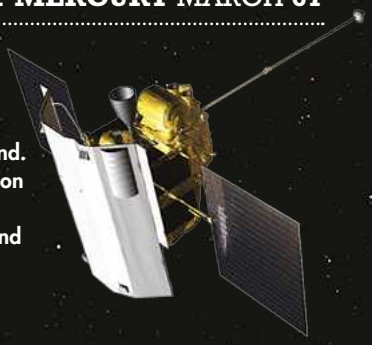


Crater Prokofiev is outlined in cyan; the yellow outline in the inset area marks the radar-bright material now known to be water-ice

NASA, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/ CARNEGIE INSTITUTION OF WASHINGTON X 9, ISTOCK, ESA

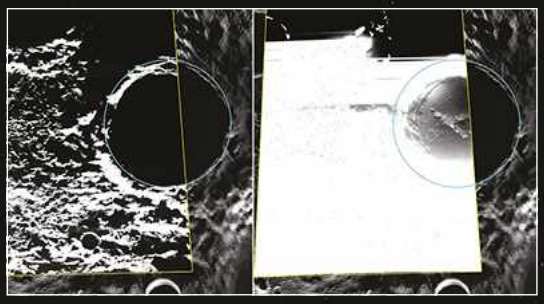
6 May 2010 ▶
Messenger captures an iconic image of two tiny points of light set against the blackness of space: Earth and the Moon seen from 183 million km away.

18 March 2011 ▶
Messenger enters into orbit around Mercury, beginning a key phase of its mission that would see it survey the planet in unprecedented detail.



17 March 2012 ▶
Messenger's primary mission comes to an end. NASA grants the mission a series of extensions, keeping it exploring and sending back data.

▼ August 2013
The spacecraft's Wide Angle Camera snaps the first ever visible-light pictures of water-ice in the shadowy craters found close to Mercury's north pole.



Spring 2015...
At the time of writing Messenger is set to end its mission by crashing into Mercury's surface during spring 2015. The study of the planet will continue, however, thanks to the vast bounty of data the craft has returned.

one crater, Prokofiev, the camera picked up an obvious light-toned area right in the region where a radar-bright feature had been detected.

"Although many lines of evidence suggested it was water-ice, it was not impossible that the bright area we saw could have been a result of the way the light scattered and the image read out," says Ernst. "To be sure, we needed a second image of the same area taken under different lighting conditions. We found that the bright region was in exactly the same spot as in the first image. This is when we were sure that what we were seeing was real!"

The exact origin of the water-ice is still a puzzle, however. "Given Mercury's proximity to the Sun, any water inherent to its building blocks would have been driven off early on," explains Ernst. "The leading hypothesis is that the ice came from the impacts of comets, volatile-rich asteroids, or both."

Final decline, final data

This is something for future missions to investigate, as Messenger's adventure is very nearly over. It has exhausted the fuel that its engines need to keep it orbiting Mercury. While an eleventh-hour engineering modification has – at the time of writing – given the probe a few more weeks in orbit, it is nevertheless destined to crash into Mercury sometime this spring.

But there is still a little bit more to come. Some of the most intriguing observations won't be acquired until the last few weeks of the mission, when Messenger will be as close as 15km from Mercury's surface for portions of each orbit. With this unprecedented data, and the vast amounts already collected, Messenger's legacy will live on for many years. "It will feel as though we've lost a close friend," says Solomon. "But we can take comfort in the fact that it has accomplished much more than was ever anticipated."

Messenger certainly won't be the last spacecraft to visit Mercury either. ESA is busy preparing its BepiColombo mission, which is due to launch to the innermost planet in July 2016. What advice, then, does Solomon have for the European team as they prepare to explore the enigmatic world?

"Mercury is in a tough neighbourhood, one in which temperatures are high and the radiation environment can be daunting," he says. "But the planet continues to deliver surprises to spacecraft designed to withstand the challenges. As one of my Messenger colleagues said more than a decade ago, 'the juice is worth the squeeze'."

► The next Mercury mission will be ESA's BepiColombo, due for launch in mid 2016

ABOUT THE WRITER
Will Gater is an astronomer, science writer and author of several astronomy books. He also appears on TV and radio to talk about space. Find him on Twitter: @willgater

CARDIFF URBAN ASTRONOMY

Elizabeth Pearson heads to Cardiff for the first in our new series focused on the UK's city-based astronomy societies

The city has never been prime astronomy real estate, with bright lights tarnishing the sky. And yet most major cities in the UK not only have an astronomy society, but these groups are some of the most active out of all the astro socs out there. This series explores some of the groups that are pushing the frontier of urban astronomy and the stunning celestial sights that can be seen from any urban back garden.

Cardiff Astronomical Society (CAS) is one of the largest astronomy groups in the UK. It all started 40 years ago, over a pint. While attending a meeting of the British Astronomical Association, Cardiff resident Dave Powell lamented the fact that his city didn't have a society, to which one of the speakers replied: "Well why don't you start one of your own then?" And so he did.

CAS now boasts some 450 members, regularly hosts star parties throughout the region and has a talk every two weeks from some of the leading astronomical minds in the country, whose aim is to reveal the science behind the sights. But no matter what is being discussed, all speakers must target a beginner audience, and it is to this that Powell attributes the society's success.

"We have never gone away from the original principle of having a society where anyone, no matter what their skill level, would feel at home," he says. "Anyone can come along to one of our meetings, hear a talk and let it fire their imagination."

Introducing new people to the stargazing community has always been one of the society's key goals. CAS runs stargazing sessions year-round, helping newcomers to navigate their way around the night sky.

"There's always this feeling that astronomy is a complicated subject, so

GETTY X 2, CARDIFF ASTRONOMICAL SOCIETY X 3

The Moon hangs over Cardiff Bay; our nearest neighbour is a great target from urban locations such as this

you have to take away that perception," says public event officer Theresa Cooper. "We'll start at something simple like the Plough, then we move from star pattern to star pattern and before they realise it they've covered most of the sky."

Tempting the public

CAS also runs solar observing sessions to give as many people the chance to look through an eyepiece as possible. During the summer months, the society pitches solar scopes beside its observatory in Dyffryn Gardens to tempt passers-by with a view of the Sun many will have never seen before. The scopes also get regular outings in the centre of Cardiff, where the society teams up with the National Museum of Wales to run astronomy days.

The society also organises excursions; members visited Bletchley Park in 2009

▲ CAS's solar scopes regularly give passers-by their first up-close glimpse of the Sun

▲ Event are often staged next to CAS's observatory in Dyffryn Gardens

As in so many cities, Cardiff's astronomers have to compete with the glow of streetlights to explore the wonders of the night sky. So whenever something really rare happens – the chance to spot a bright comet for example – many will take their kit beyond the city walls. Cardiff benefits from being surrounded by countryside, meaning that astronomers don't have to travel far to experience a relatively dark sky. For those willing to drive a bit farther, the Brecon Beacons, an International Dark Sky Reserve, offers some of the darkest nights in the country.

▲ Nearby are the Brecon Beacons, an International Dark Sky Reserve

For those who prefer to stay put when the sky is clear, the society holds regular public stargazing events – though organising them has proved tricky. "In the city centre you have to apply to the council. You might have to give them a deposit and a lot of notice, and they might want you to go to a certain place," says Cooper.

Often these designated locations are far from popular areas, so attracting passers-by is difficult, but the society has run several successful events in the Cardiff Bay region. Though at night the area is brightly lit, making it difficult to see much, there are some who see advantages in this for the first few times you're stargazing. "Light pollution blots out faint stars, so you can only see the main stars and patterns," says Cooper.

The society has always found that there is plenty to capture the interest despite light pollution, as long as you don't expect to see a perfect view from the outset. ▸

THE OBSERVATORY

CAS has its own dedicated observatory just outside the city, available to any member who wants to use it

The observatory has seen plenty of use since it was opened in 2010

The CAS observatory opened in 2010 after many years of hard work by the society. "I'd always had plans to build an observatory but the question was always where," says founder Dave Powell.

The society had little luck in trying to find a site within the city, as all sites suggested by the council were unsuitable. It was only when they turned to Dyffryn Gardens in the Vale of Glamorgan, a little under 5km outside the city and owned by the National Trust, that they finally managed to find a place to build the observatory. Though a short drive away, the site offers much darker skies than can be found anywhere in the city centre.

"The statutory rules for lighting are tough in the Vale of Glamorgan," says Powell. "You can see the Milky Way – the sky is very dark here because there are no lights at all."

It took several years to plan, build and equip the observatory, but it has seen a lot of use since the ribbon cutting. Any society member can use the telescope once they have been trained, but it is most frequently used to introduce the public to the night sky. CAS regularly runs sessions with local groups such as the Guides, the Scouts and the Women's Institute, teaching them how to navigate the heavens.

This was made even easier when they upgraded from a 20-year-old 12-inch telescope to a much more advanced 11-inch with a tracking mount, which lets newcomers track down amazing sights easily.

"It's absolutely brilliant," says Powell. "For those that don't know their way around the night sky it's just great. You press the buttons and away it goes."

▸ "People see images taken of Jupiter from a dark-sky location," says Powell. "When they look through their 4-inch refractor in the middle of a light-polluted city and all they see is an orange blob they think 'Oh that's it? I'm not doing it right'. But if you have a small telescope or a set of binoculars you can spend years looking at the Moon, variable stars and meteor showers."

Looking up at the urban sky also helps to keep costs down; the best equipment isn't always a massive – not to mention expensive – telescope with the latest accessories and add ons. Instead a good pair of binoculars that can be grabbed whenever the sky looks clear are often a better option. "You need nothing really," says Cooper. "You need your eyes and a star chart and you're well on your way." S

To find out more or join the society, email secretary@cardiff-astronomical-society.co.uk or visit www.cardiff-astronomical-society.co.uk

CARDIFF ASTRONOMICAL SOCIETY, ISTOCK X 3

TOP 3 CITY SIGHTS

THE PLANETS

Constantly wandering the night sky, the planets are a great sight for beginners. Venus is the brightest object in the sky after the Sun and Moon; it can be seen with the naked eye, as can Mercury, Mars, Jupiter and Saturn. With binoculars it's possible to make out the four Galilean moons of Jupiter, while a small scope will reveal Saturn's rings.

THE MOON

Though it's the most familiar object in the night sky, the Moon has plenty of hidden depths that can be revealed with binoculars. The best time to observe the Moon is when it is partially illuminated, as the boundary between light and dark sides – a line known as the terminator – gives lunar craters and cliffs a greater contrast, making them easier to see.

ASTERISMS AND CONSTELLATIONS

Asterisms and constellations are useful for finding your way around the night sky, but under the haze of light pollution only the brightest can be seen. The Plough asterism in Ursa Major, visible year round, is a good starting point for finding bright asterisms such as the W of Cassiopeia and the constellations of Gemini and Leo.

Check out the *Sky Guide* on page 47 to find out which planets, asterisms and constellations will be visible this month.

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s staff writer. She gained her PhD in extragalactic astronomy at Cardiff University.

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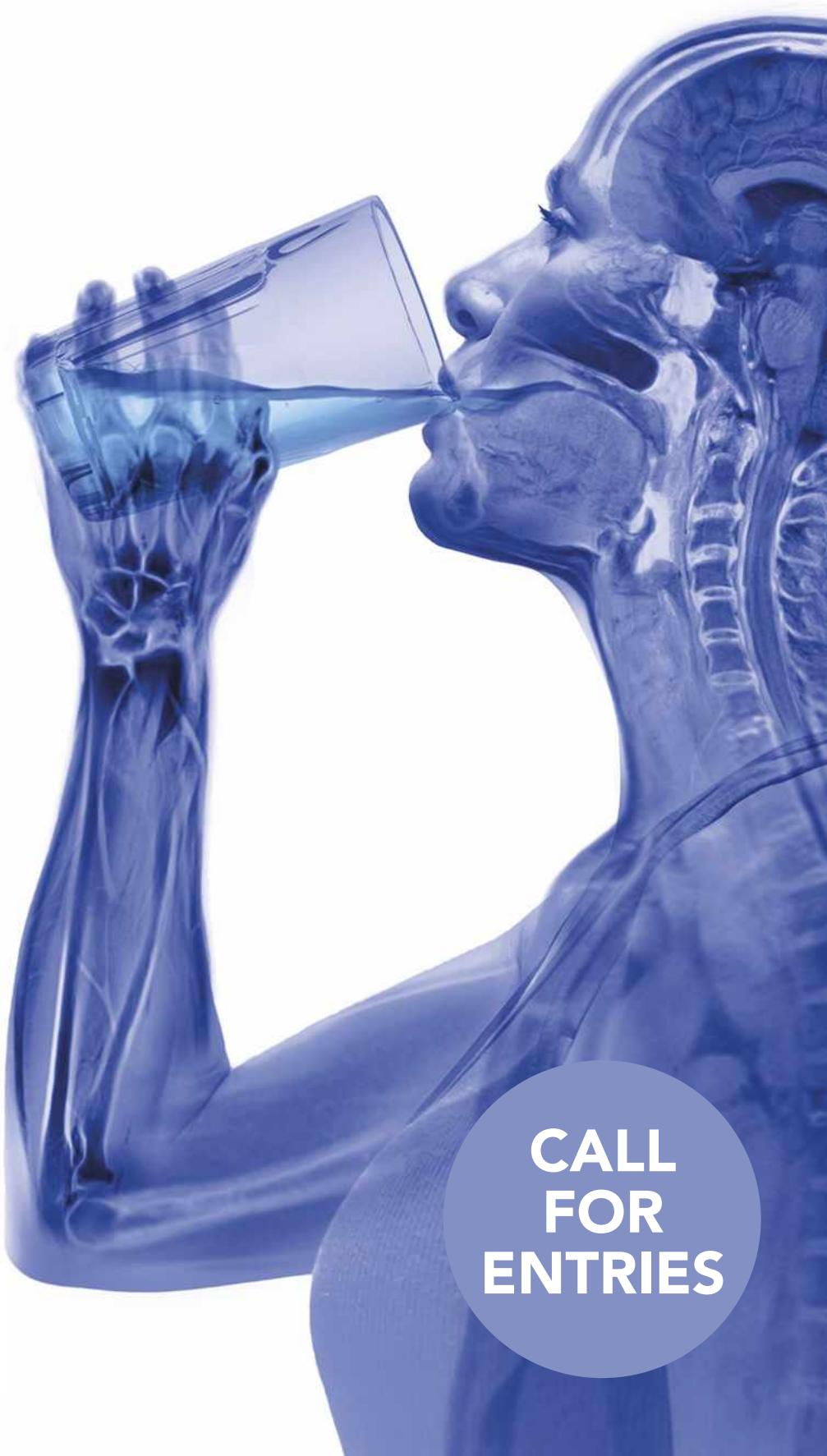


© **HUGH TURVEY,** Woman Drinking Water 2010

VISUAL OBSERVING GUIDE

PART 3: SUPERNOVAE

The final instalment of **Paul Abel**'s guide to visual observing turns the scopes on supernova hunting

In 1054 Chinese astronomers noticed the arrival of a new star in the sky. Back then, such objects were known as 'guest stars'. Today, we know this 'guest' wasn't a new star at all, but an old one that had exploded in a cataclysmic event known as a supernova.

Supernovae are among the most destructive events that nature can produce. When they happen, a single star, previously lost in the glare of the combined light of a billion Suns, will flare up and outshine its entire galaxy. Studying supernovae not only provides important clues about star death, but also tantalising details about the expansion of the Universe and the origins of heavy elements. ▸

PAUL WHITFIELD


All that remains of the 'guest star' seen by Chinese astronomers is the Crab Nebula, M1

▸ There's a wonderful mystery surrounding supernovae. You never quite know when the next one will be, and when one does occur you have to be quick. You only have a small amount of time before it fades back into obscurity.

Supernovae occur for two reasons: either as the final death throes of a massive star or because a white dwarf has attempted carbon burning. It is inside these cosmic fireworks that heavy elements are made, and in their afterglow, these elements are returned to the interstellar medium where they will eventually become part of new stars, planets and possibly life.

Although spectacular, supernovae are rare. In our own Galaxy we would expect between one to three supernovae per century, and the last one that was visible to the naked eye occurred in 1680. Stars like Betelgeuse (Alpha Orionis), Antares (Alpha Scorpii) and Rho Cassiopeiae are all candidates. All of these stars have started their journey towards a violent death – it's not a question of if, just when.


Betelgeuse, the red star in the shoulder of Orion, is a good candidate for going supernova

> "You never quite know when the next supernova will be, and when one occurs you have to be quick"

Supernova observation falls into two categories: searching and monitoring. And as visual observers, we are well placed to make valuable contributions to this exciting field of amateur astronomy. Since supernovae are so rare, we have to search long and hard to find them. The way to do this is to examine as many galaxies as possible, searching their elusive patchy glows for new faint pin-pricks of light. Now is a particularly good time to start since Earth is currently turned away from the centre of the Milky Way and facing out towards extragalactic space. The springtime galaxies of Leo, Virgo and Coma Berenices are well on view.

Beginning your hunt

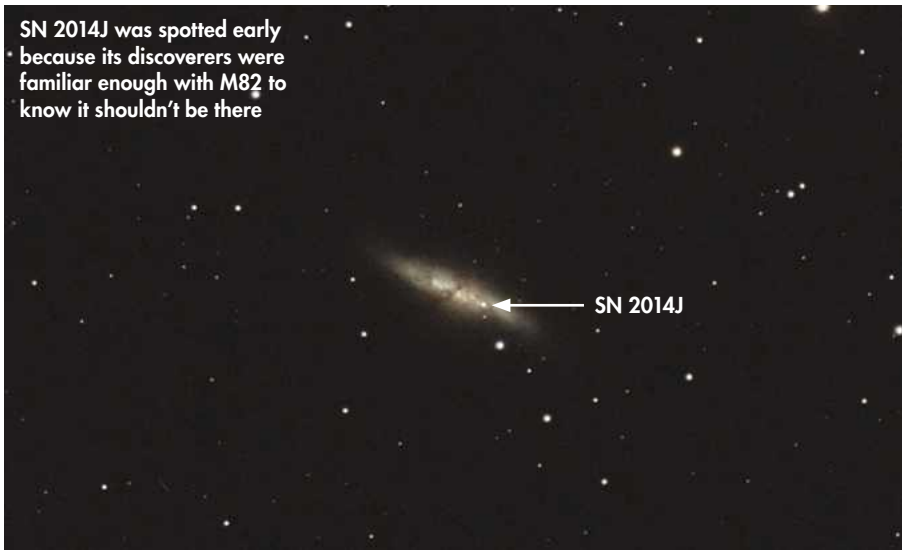
To visually hunt for supernovae, you will need a telescope that can see a reasonable number of galaxies, so probably 6 inches in aperture at least. You will also need to be familiar enough with the sky that you can find them fairly quickly. Fortunately there are a number of bright galaxies out there – find our starter list on page 76 – and you should survey as many as you can in one night. You will need to become familiar with how these galaxies look if you are to detect any faint supernovae in the future. Making sketches is extremely helpful in this regard. Examine each galaxy at a medium power (say 100x) and repeat the observations as often as possible.

It has to be said that imagers have had a great deal of success here for one simple

reason: the more galaxies you can survey in a night, the better your chances of scoring a supernova. Veteran hunter Tom Boles has clocked up a staggering 155 discoveries from his observatory in Suffolk using CCD imaging. But occasionally, supernovae are discovered by accident.

In January 2014 University College London lecturer Steve Fossey was training four undergraduate students in imaging M82, the Cigar Galaxy in Ursa Major. In doing so they discovered SN 2014J, a supernova that was just beginning to become visible. However you find it, if you do suspect that you've discovered a supernova alert Guy Hurst, the British Astronomical Association's (BAA's) supernova patrol coordinator (**editor@theastronomer.org**).

If a supernova is reported and it is within the magnitude range of your telescope, you should begin observing at once. Your main goal is to make as many magnitude estimates of the supernova as often as possible so that a light curve can be obtained. For this, you will need a star chart that has suitable comparison stars and their magnitudes listed. When SN 2014J was reported the American Association of Variable Star Observers (AAVSO) produced an excellent comparison chart showing the location of the supernova in M82 and a number ▸



SN 2014J was spotted early because its discoverers were familiar enough with M82 to know it shouldn't be there

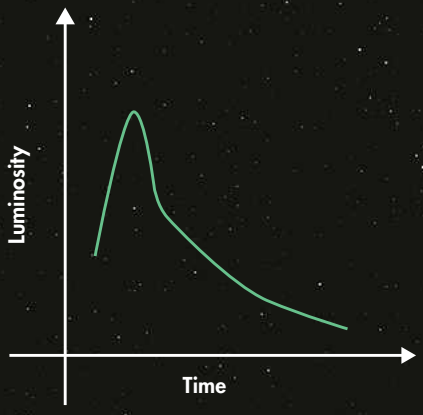
TYPES OF **SUPERNOVAE**

We can classify supernovae into two distinct types

TYPE I

These occur in binary star systems when a white dwarf star is able to accumulate material from a nearby companion, causing the temperature of its core to start rising. If it can attract enough material, carbon fusion will start in the core. A few seconds later a runaway fusion reaction occurs and the star explodes, producing a supernova.

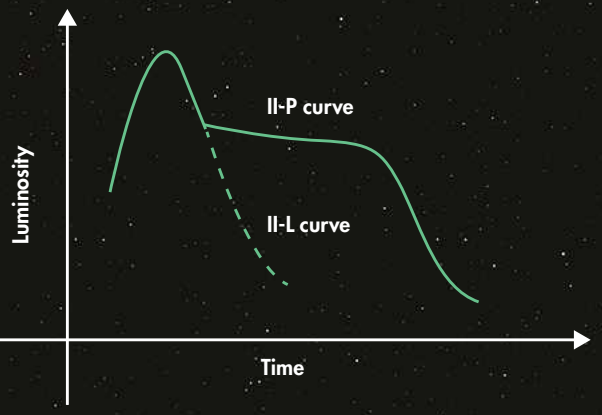
The light curve of this type of supernova is very distinctive: there's a peak in magnitude and then the luminosity slowly drops off. Due to the nature of the explosion, Type Ia supernovae are considered excellent 'standard candles' for measuring distances in space.



TYPE II

This type of supernova is produced when a star that is at least eight solar masses begins to collapse. Once stars of this size run out of hydrogen, they start burning other elements: first carbon, then neon, oxygen and finally silicon. Eventually the core becomes too heavy and collapses, producing a supernova.

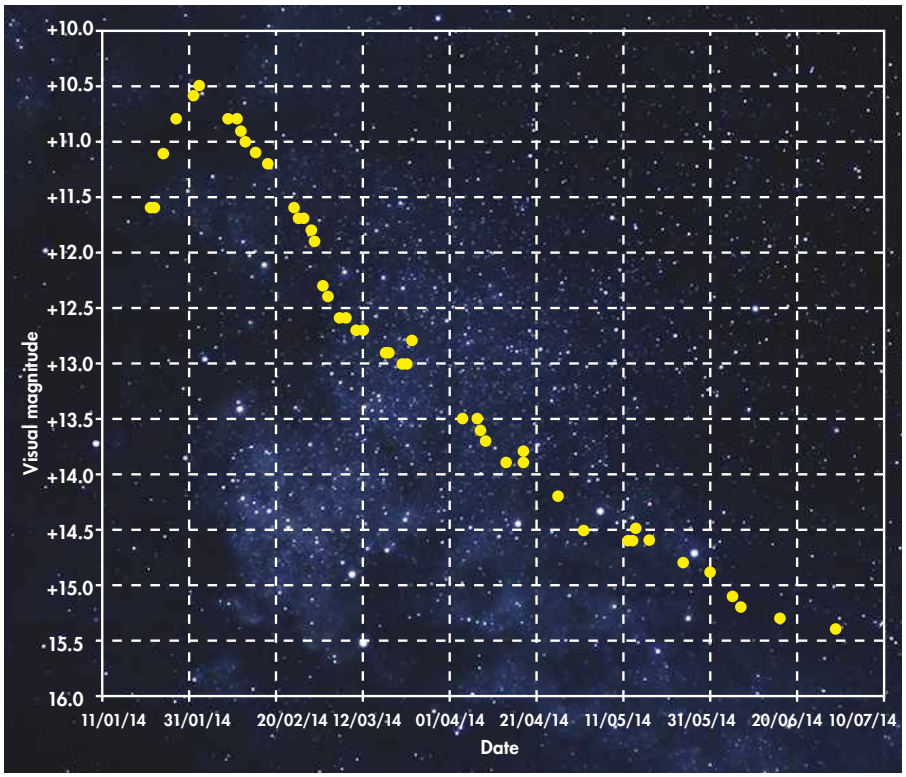
Type II supernovae fall into two subcategories depending on the light curves they produce. A II-L curve shows a linear falling off, while a II-P curve shows a distinctive plateau and the luminosity drops off at a much slower rate.



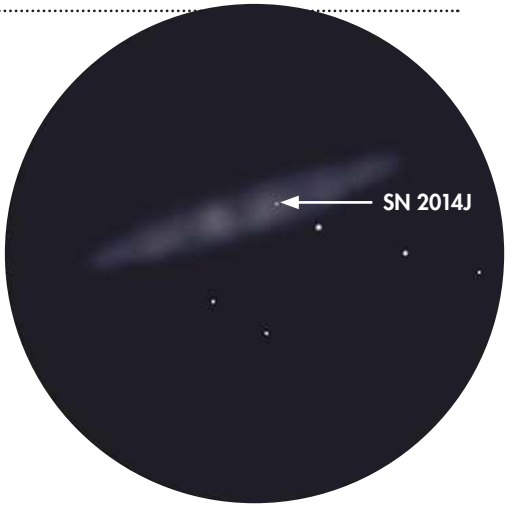
THE VALUE OF **LIGHT CURVES**

The reason we want to make as many magnitude estimates of a supernova as possible is so that the data can be plotted on a graph to produce a light curve like the ones above. Not only does the light curve allow us to classify the type of supernova, with enough data professional astronomers can estimate the mass of the progenitor – and therefore determine the type of star that produced the original explosion.

You can generate your own light curve by simply plotting your magnitudes against time in a spreadsheet. Alternatively, the BAA and AAVSO websites can do this for you if you enter your observations online.



▲ With a sharp peak and steady drop, this light curve reveals SN 2014J to be a Type Ia supernova



▲ The author's rendition of SN 2014J; sketches are useful as they can reveal gradual changes

▸ of good comparison stars to use. To estimate a supernova's magnitude, use same method as we did for variable stars in the February 2015 issue. You should record your observations in the same way as for variables: in a log book note down the date, time, estimated magnitude and deduced magnitude. For tips keeping one, see *The Guide* on page 78. Personally, I like to make a drawing too, as it shows the location of where the supernova was and how it changed as it faded. For example, SN 2014J had a distinctly yellowish hue that got a little stronger as it started to diminish in brightness.

As we have seen frequently throughout this series, your observations are of no use if they just sit on a bookshelf. Both the BAA (**www.britastro.org**) and the AAVSO (**www.aavso.org**) will be very glad of them. Your data can be added to the growing body of observations used by professional astronomers. Despite the prevalence of digital cameras, visual observing still has a place in modern amateur astronomy. There are plenty of ways in which to make meaningful contributions: all that is needed is a telescope, dedication and clear skies.

ABOUT THE WRITER

Dr Paul Abel is an astronomer based at the University of Leicester. You can listen to him on our Virtual Planetarium each month.

START WITH THESE **GALAXIES**

Many galaxies worth patrolling are visible now; the ones marked with an asterisk have produced supernovae in the recent past

GALAXY	LOCATION	MAGNITUDE	TYPE	APPROXIMATE DISTANCE
M81* (Bode's)	Ursa Major	+6.9	Spiral	12 million lightyears
M82* (Cigar)	Ursa Major	+8.4	Starburst	12 million lightyears
M65	Leo	+10.3	Spiral	35 million lightyears
M66	Leo	+8.9	Spiral	36 million lightyears
M61*	Virgo Cluster	+10.2	Barred spiral	52 million lightyears
M64 (Black Eye)	Coma Berenices	+9.4	Spiral	24 million lightyears
M101* (Pinwheel)	Ursa Major	+7.9	Spiral	21 million lightyears
M51* (Whirlpool)	Canes Venatici	+8.4	Spiral	23 million lightyears
M104 (Sombrero)	Virgo	+9.0	Spiral	28 million lightyears
M84*	Virgo	+10.1	Elliptical	60 million lightyears
M85*	Coma Berenices	+10.0	Elliptical	60 million lightyears
M60*	Virgo	+9.8	Elliptical	55 million lightyears

CHART BY PAUL WOOTTON, PAUL ABEL, ISTOCK

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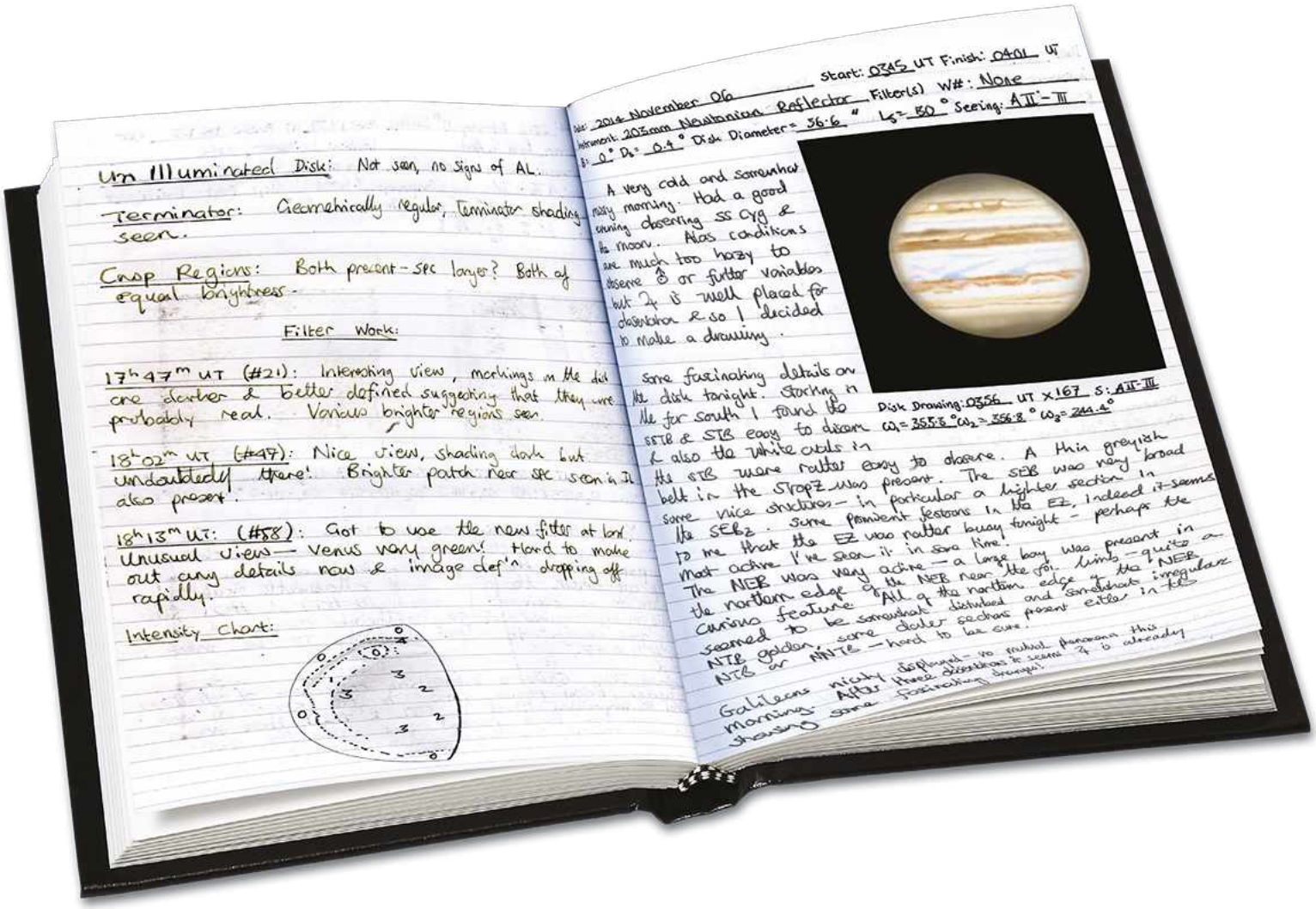
The Guide

Keeping an astronomical log book

With **Paul Abel**

How making notes can improve your observing experience



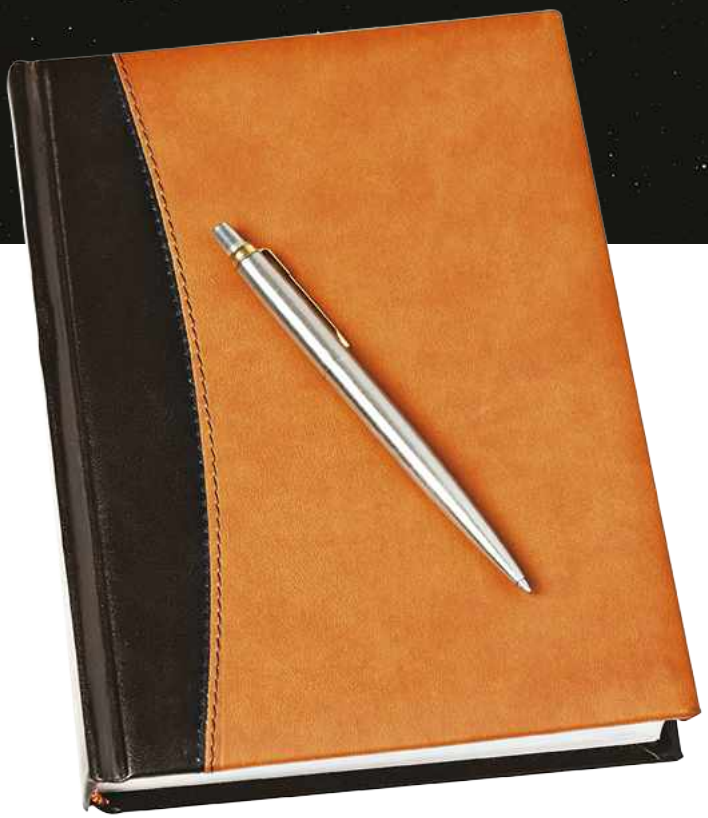
▲ **Two pages from one of the author's log books; detailed notes and drawings will help you to spot patterns and anything out of the ordinary**

PAUL ABEL X 2, ISTOCK X 2, ROBIN SCAGELL/GALAXY

The journey from absolute beginner to seasoned amateur is full of poignant personal cosmic discoveries. Your adventures out in the Universe will be marked by a number of important first time events – locating a much sought after Messier object or seeing the polar ice caps of Mars for the first time, perhaps. But if you are to build on these first glimpses, you must accurately record what you have seen.

Keeping a log book will transform you from a casual viewer to a reliable observer. Observation is much more than just looking through the eyepiece of a telescope. By writing up your observations in a systematic way you'll find that your eyesight sharpens; you can look back and see how your observing and drawing skills have improved; you'll have a tangible past on which to build. By repeating observations, old friends will be revealed in a new light, their subtle aspects slowly coming to the fore. All of this will make astronomy much more rewarding.

There's also a scientific aspect to keeping a log book. You may be able to provide confirmation of a rarely observed phenomenon such as a bright fireball, or the beginnings of a dust storm on Mars. If you have no accurate record of what you have observed, you may never know if you have seen something important.



▲ Make sure you choose a strong hardback notebook that can stand regular use; consider investing in several for different targets

By recording your observations in a consistent manner, you'll find that your whole approach to astronomy shifts into a much more rewarding pursuit: rather than just checking off objects you have seen, you can begin to study them properly. This will allow you to specialise and decide which aspects of astronomy interest you the most. There are still many areas where amateurs can make useful contributions, including planetary and variable star work, provided observations are recorded systematically.

A tome to last

The log book itself should be sturdy, hard backed and contain good quality paper. It's worth spending some money on it as I've had books that have fallen to pieces after a couple of months under the British winter skies! Loose-leaf observations in ring binders should be avoided, as it is only a matter of time before individual entries become lost.

What you record will largely depend on what you are observing. Although there are some standard things you must always note down – such as the date, time and the details of your telescope – some are specific to the type of object you are looking at. Planets, for example, require drawings that provide an important visual impression of what you've seen, along with details such as phase and disc size. Variable stars require no drawings, but will need magnitude estimates and details of the finder chart used.

For this reason, you might want to keep a log book for each object. I have separate books for all the planets, variable stars, solar work and the deep sky. I make my rough drawings and observations outside, then make a neat copy in my log books indoors afterwards. This makes the layout easier, with drawings on one page, and written notes on the following. Make your drawings on a separate piece of paper and stick them into your book, as you may need a few attempts at rendering them.

Your log books will be your observing legacy – you should regard them as one of amateur astronomy's essentials.

Paul Abel is a visual observer who appears on our Virtual Planetarium

WHAT TO **RECORD**

DATE The full date in the format yyyy-mm-dd.

TIME The time of each observation in UT.

TELESCOPE The size of telescope and its type (Newtonian, Schmidt-Cassegrain, etc).

MAGNIFICATION The powers you use for drawings and observing.

EYEPIECES Focal length, and whether you used a star diagonal or Barlow lens.

FILTER WORK Include the Wratten number (printed on the side of the filter) of any filters used.

SEEING This is a measure of how steady the atmosphere is. Use the Antoniadi scale from I-V, where I is a perfectly sharp image and V is an unfocused blob.

OTHER CONDITIONS Any cloud or mist present, moonlight, etc.

TARGET-SPECIFIC DETAILS For planets, note the value of the central meridian, phase (if applicable) and disc size. For deep-sky objects and comets, indicate north in any drawings and include the constellation. Variable stars require magnitude estimates.

PERSONAL THOUGHTS Make a note of anything else that strikes you as interesting or unusual.

THE VALUE **TO SCIENCE**

Keeping a log book is more than a personal endeavour: the details you record can help contribute to real science. Variable star enthusiast Gary Poyner has clocked up a total of 269,753 variable star observations. The records from his log books allow light curves of a number of variables to be extended back into the 1970s. One of the greatest visual observers was British amateur George Alcock, who discovered five comets and five novae with binoculars – the last at the age of 78. His logs were full of meticulous notes and fine drawings of the objects he'd discovered.

▲ Alcock was a firm proponent of binoculars – all of his discoveries were made using them

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The Widescreen Centre News & Events

Huge thanks to all of you who supported Widescreen at Astrofest recently. Put it in your calendars now - 2015's International Astronomy Show is be October 2nd-3rd.

2015 continues with the Solar eclipse Friday March 20th. It peaks at around 9.30am with the Sun at an elevation of 29deg. At 97% it ill be dramatic - but you will need a solar filter or solar telescope. Consider Baader Astrosolar film (£20) or a Herschel Wedge (call) or ask us about the **Daystar Quark** & Lunt 35/s & 50s. Remember - **BBC Stargazing LIVE** is that weekend (March 19th-21st)

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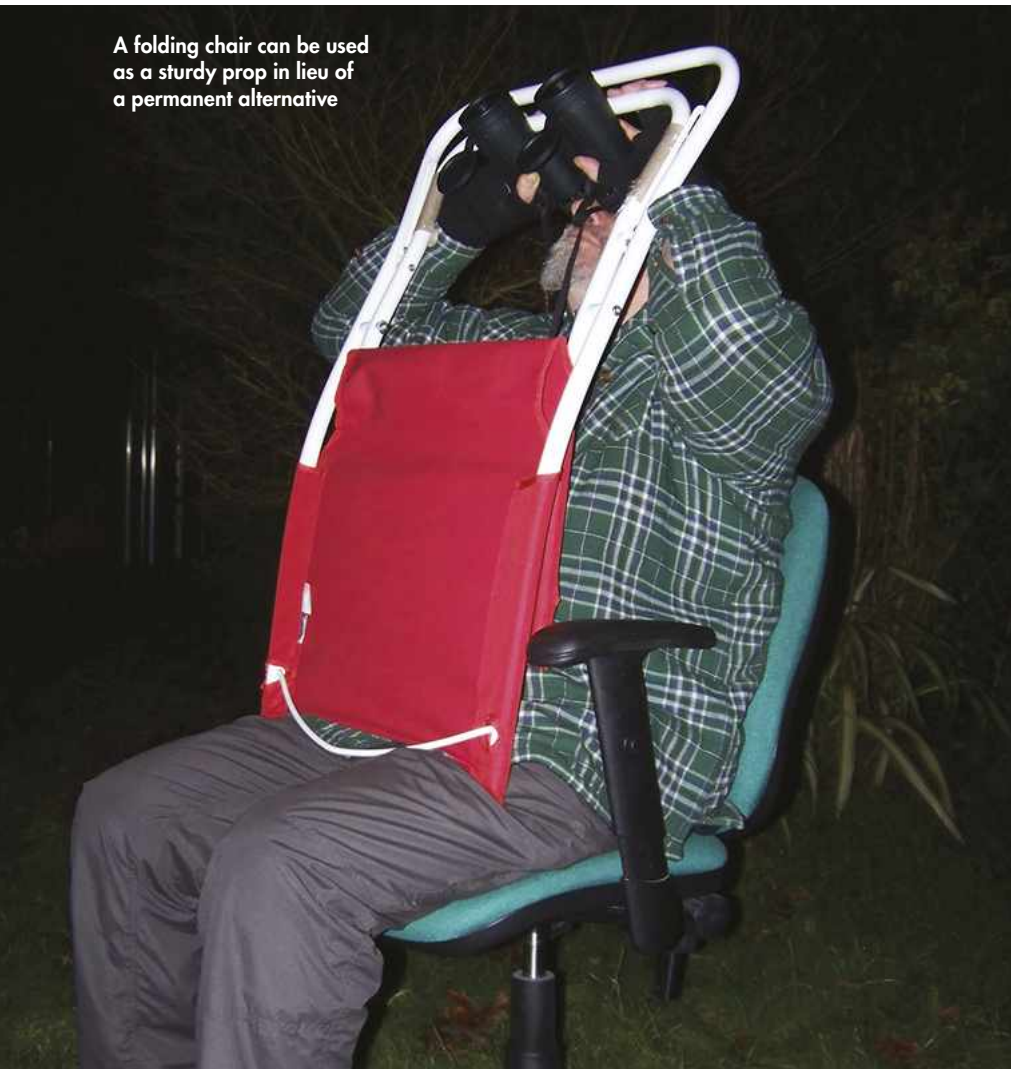
With **Stephen Tonkin**

How to

Steady binoculars with items found around the home

Money-saving tips to help you stargaze free of arm fatigue



A folding chair can be used as a sturdy prop in lieu of a permanent alternative

ALL PICTURES: STEPHEN TONKIN

TOOLS AND **MATERIALS**

A COMBINATION OF THE FOLLOWING

A cap with a stiff peak; a block-headed push broom; a flat-head or bow-head garden rake; a window-cleaner with a tilt-head and a telescopic extensible pole; a fold-flat beach chair or some other folding chair; a clean tea towel, duster or small hand towel; a selection of bungee cords.

During any binocular observing session there will come a time when you want steadier views than you can get just from holding them, and there won't always be a convenient fence or car roof on which to rest your elbows. Many of us who regularly observe with binoculars have some kind of mounting system, but most casual stargazers do not. However, your home can provide some very usable alternatives.

There are many advantages to supporting your binoculars in some way. Close double stars are easier to split; Jupiter's Galilean moons are easier to see when they are close to the planet's bright disc; fainter objects become visible due to their light being concentrated into a smaller area of a non-shaking field of view; and arm fatigue is considerably reduced.

A well-fitting cap with a stiff peak is small enough to be easily portable and is surprisingly effective at stabilising views when it is gripped while holding binoculars up to your eyes. You will probably find it best suited to smaller binoculars, especially those with roof prisms, which are easier to hold comfortably to the peak. An advantage to this way of supporting binoculars is that it does not limit you to any observing position: it can be used whether you are standing, sitting or reclining.

If you want more stability, you will need a more rigid option. Essentially you want an item with a pole, so that one end can rest on the ground and at the other there is something to which you can secure your binoculars. Suitable items that you may

already have include flat-head and bow-head rakes, block-headed push brooms (not besoms or corn brooms), draw-hoes and window cleaners. Brooms and rakes are usually of a length that make them more suitable to seated observing.

Because of their normal use, the end on which you place your binoculars is likely to be dirty, so use something like a small hand towel or tea towel to cover the business end of the tool and protect your binoculars.

It's possible to use these tools as simple supports just by resting your binoculars on them, but generally you'll find your makeshift mount easier to use if you secure your binoculars with a bungee cord. The bungee needs to be tight enough to stop the binoculars slipping off, but not so tight that it restricts their freedom of movement, making it difficult to scan a reasonably large region of sky without having to continually reposition the bottom end of the tool. The arrangement shown in Step 2 achieves this but, however you do it, make sure that the tension on the bungee hook pulls it away from you, so that the cord won't whack you in the face if it slips off!

Tools such as window cleaners with telescopic extension poles are much more versatile: they allow you to observe standing up, which offers more freedom of movement, and the adjustable pole length makes it easier to vary the altitude range at which you are observing. If the binoculars are held away from the pole by an adjustable tilt-head, you will be able to observe at very high altitudes without having to tilt the pole much.

Sitting solutions

Home-made binocular chairs often incorporate some sort of supporting frame for either your elbows or the binoculars themselves. Lightweight beach chairs can be used for this purpose, but do ensure that you prevent them from opening in use and trapping your fingers; bungee cords, cable ties, strips of Velcro, adhesive tape or string can be used for this. Although elbow support is not quite as steady as pole-mounted support, it can be much more comfortable.

Try some of these ideas or, better still, invent your own and see what best suits you. The more steadily you can hold your binoculars, the more likely you are to enjoy using them, and you're also likely to find your observing sessions become much more productive.

Stephen Tonkin writes the *Binocular Tour* in our *Sky Guide* section every month

STEP-BY-STEP GUIDE

STEP 1

A cap with a stiff peak makes a simple, portable binocular support that's best suited to smaller binoculars. Simply make sure that your cap is firmly on your head and 'sandwich' the peak between your fingers and the top of the binoculars.

STEP 2

If you're going to use a broom or a rake as a support, it's a good idea to cover the business end with a cloth, such as a clean hand towel, tea towel, jay cloth or duster. This will prevent any dirt from being transferred to the binoculars.

STEP 3

Because of their length, tools like rakes and brooms are best suited to seated observing. For safety and ease, use a bungee cord to secure the binoculars to the covered end of the tool being used. This will give you greater freedom of movement.

STEP 4

A long window cleaner is very versatile. The telescopic handle can be easily altered for height, and the adjustable tilt-head holds the binoculars away from the handle, enabling you to get underneath the binoculars so that you can observe objects at high altitudes.

STEP 5

A folding chair is often the ideal width to use as an elbow rest. Use a bungee cord, Velcro strap or similar to stop it from opening and trapping your fingers. If you are observing in a seated position, simply place the chair across your lap.

STEP 6

A folding chair is also useful on a recliner, so long as the recliner has sling-type arms. In this case, put the folded chair across the arms and rest your elbows on it. You can easily change elevation by slightly changing your position or the angle of the folded chair.

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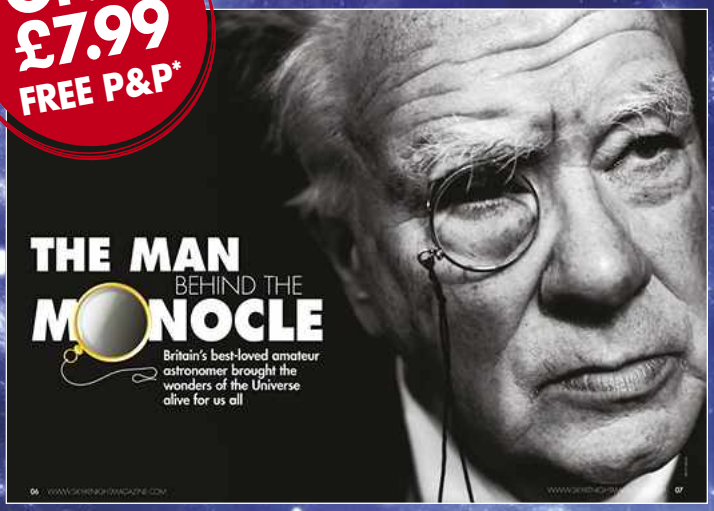

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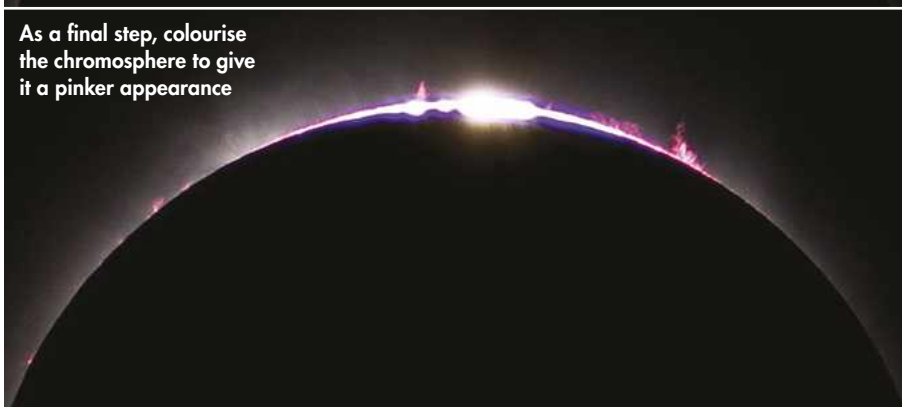
Image processing

The Sun's chromosphere during totality

With **Daniel Lynch**

Daniel's starting image proves you can get great base shots with a simple setup

Tweaking exposure and contrast can reveal extra coronal details



As a final step, colourise the chromosphere to give it a pinker appearance

ALL PICTURES: DANIEL LYNCH

A total solar eclipse is such a rare and spectacular phenomenon that most who witness it will be tempted to photograph it. However, capturing an image that does justice to what you can actually see with the eye is extremely challenging.

The main problem lies with the extreme range of brightness seen during totality. The chromosphere, a layer of the Sun visible briefly before and after totality, is vividly pink and brighter than a full Moon, but the outer corona – a plasma with magnetic structure – extends out into space with a faint brightness that would test even the best eyesight.

Despite giant leaps in hardware, it is impossible to capture both chromosphere and corona with a single shot. Photographers call the differing levels of brightness 'dynamic range', and the human eye is still better at interpreting scenes with high dynamic range than any single camera. With that in mind, almost every serious astro imager will edit their photos to give a more faithful reproduction of the eclipse.

We're going to use Photoshop here, but GIMP, Paintshop Pro or Lightroom will do an equally excellent job. Our base image file is in the RAW format. The shot we're looking at is a high-magnification picture of the chromosphere, captured with a DSLR and a 2.75-inch refractor that cost £50 in a retail store. For such a cheap setup, I was thrilled with the resulting photograph, the uppermost of the three on the left. Even still, I felt that the chromosphere could be clearer.

Opening a RAW file in Photoshop brings up the Camera RAW pallete. Using this pallete you can alter almost every aspect of the photo; all of the tweaks we are going to make can be done from here.

It is extremely difficult to get the correct exposure during totality as the light intensity changes so rapidly. Therefore my first adjustment was to the Exposure slider; increasing exposure increases the brightness. Altering the Contrast and Clarity sliders can also help. In my case, they allowed me to make out a faint coronal loop, leaving me with the middle image of the column.

In order to bring out the correct pink colour, I increased the Saturation and Vibrance sliders by 20 and 10 respectively. Two more handy sliders that can be used are Tint and Temperature. I found that 5,000 was about right for Temperature and 11 for Tint. It is definitely worth adjusting these sliders back and forth until you get the rendition that looks the best, but be careful not to overdo it.

With this final adjustment, the deep red and pink colour of the chromosphere was now faithful and it gave the best possible view of the coronal halo. A final but crucial piece of advice: if this is your first eclipse, please don't spend it fiddling with your camera settings. Have a clear plan of what you want to capture and set aside one minute for photography at most. Too many people have forgotten to look up and truly appreciate one of nature's greatest spectacles.

Photographer Daniel Lynch has not missed a total solar eclipse since 1999

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Main image of Pleiades M45 Cluster taken using Vixen Polarie Star Tracker © John Slinn

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With **Steve Richards**

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Reduce the risk of scratches by removing as much dust as you can before cleaning

What is the best way to clean the corrector plate of a Schmidt-Cassegrain telescope?

STEWART WHITE

As with all telescopes, cleaning the optical surfaces should only be undertaken if it is absolutely necessary, as there is a risk that you will do more harm than good. Small amounts of dirt will have no detrimental effect on your observing experience; lens surfaces and their coatings are very resilient, but there is no need to put this to the test without good reason.

However, if the corrector plate really does need to be cleaned, it is important to ensure that it is as dust free as possible beforehand, to make sure that there is nothing to scratch the lens surface as you clean it. Using a good bulb-type puffer with the brush removed is very effective, but never be tempted to use the supplied brush as this can carry grit and grease over to subsequent cleaning sessions. If you have a stubborn particle that won't blow off, spray some spectacle cleaning fluid onto the tip of a cotton bud and dab (but don't rub) the spot to release it.

Once you are sure that there are no particles left on the lens surface, spray some spectacle cleaning fluid onto a lens cleaning tissue and gently clean the whole lens surface, working from the centre outwards. While the lens surface is still wet, gently dry it with a fresh microfibre cloth.

STEVE'S TOP TIP

Should I let my scope cool down before observing?

Unless your telescope is stored outside, it is vital to give it plenty of time to cool down to the ambient temperature before an observing session – this is called 'reaching thermal equilibrium'. Without a proper cool-down you will get disturbed air moving within the telescope, causing what are known as tube currents. These tube currents distort the view through the telescope in much the same way as poor seeing in the atmosphere reduces clarity. Ideally, Newtonians and refractors should be allowed to cool for about an hour, and Schmidt-Cassegrains and Maksutovs for a couple of hours.

I own a Sky-Watcher Heritage 130P Tabletop Dobsonian and have trouble angling my face to use its straight-through laser finder. Is there an alternative?

KEITH J PARRY

The Heritage 130P's finder is very close to the scope

STEVE MARSH, SKY-WATCHER

This is a very common problem, especially with reflectors where the finder is located near the front of the optical tube and you have to twist your head along the side of the telescope in order to view the red dot. The advantage of a finder like yours is that it is very intuitive to use but there are indeed alternatives.

Your problem is compounded by the fact that the finder itself is mounted very close to the telescope. You should replace your existing finder with another red-dot type, but on an extended mount, to move your head away from the telescope. The Rigel QuikFinder compact reflex sight does exactly this, giving you a non-magnified sighting system that projects a pair of red concentric rings onto the view of the sky, but as it is four inches tall it is much easier to align with your eye. As an optical alternative, you could also consider a Sky-Watcher 9x50 right-angled erecting finderscope.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

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90
A 6-inch Newtonian with Go-To designed with beginners in mind

This month's reviews

First light

Books

Gear

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FIRST **light**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/stardisc150P**

Sky-Watcher Star Discovery 150P Go-To reflector

A beginners' Go-To telescope that is accurate and versatile

WORDS: PAUL MONEY

VITAL STATS

- **Price** £399
- **Optics** Parabolic primary mirror
- **Aperture** 150mm (6 inches)
- **Focal length** 750mm (f/5)
- **Mount** Computerised single fork arm altaz
- **Handset** SynScan V4 (42,900 object database)
- **Power** 12V DC 1 Amp power supply (tip positive) or eight AA batteries
- **Extras** 25mm and 10mm eyepieces, 2x Barlow lens, red-dot finder, tripod
- **Weight** 18kg
- **Supplier** Optical Vision
- **www.**opticalvision.co.uk
- **Tel** 01359 244200

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The market for beginners' telescopes is still going strong, thanks in part to programmes such as *The Sky at Night*, *Stargazing LIVE* and the recent revamp of *Cosmos*. Demand gives impetus to telescope makers to come up with new products, and Sky-Watcher is certainly keeping pace with its Star Discovery 150P, a 6-inch Newtonian reflector on an altaz Go-To single arm mount. It is supplied with a tripod, a basic red-dot finder, two 1.25-inch eyepieces (25mm and 10mm) and a 1.25-inch 2x Barlow lens, which is threaded so that you can attach a camera.

The mount has a battery compartment that takes eight AA batteries, as well as a port for an alternative power supply such as a power tank. Also on the mount is a connection for the handset and a 'snap' port for camera control: you could dispense with the telescope entirely, replacing it with a DSLR mounted on a camera bracket to record landscape or timelapse images. The handset packaged with the Star Discovery 150P is the SynScan V4, which is slightly larger and a little more bulky than the more prevalent SynScan V3, though the arrangement and function of the control buttons are identical to previous versions. It offers a rich variety of targets, with nearly 43,000 objects in its database.

There are two alignment routines to choose from, brightest star and two star. The first method divides the sky into zones (north, south and so on) and suggests stars to use for alignment in the zone you've chosen. The second allows you to choose any stars in the sky. Both resulted in good slewing, with targets usually placed in the central 50 per cent of the view in the 25mm eyepiece.

SKY SAYS...
Tracking was generally good, with targets remaining close to the centre of the view for up to 20 minutes

Travelling through the sky

Using the same eyepiece, we aimed at Aldebaran in Taurus to test the quality of the field of view: we were pleased to find that the star appeared pin sharp across 75 per cent of the view with only a little coma showing up towards the field edges.

The Star Discovery 150P has a focal length of 750mm, giving the system a focal ratio of f/5. Therefore the 25mm and 10mm eyepieces give magnifications of 30x and 75x respectively – a nice range for a beginners' scope and one that doesn't push the optics too much.

The 25mm eyepiece provided a wide field of view that allowed us to take in the whole of the Pleiades and almost all of the Sword of Orion. The 10mm gave a good increase in magnification and in moments of ▸

FREEDOM TO EXPLORE

One of the technologies that Sky-Watcher originally developed for its more sophisticated mounts – but is now appearing in its more basic products such as the Star Discovery 150P – is Freedom Find. By making use of dual axis digital encoders, the mount can be physically moved in either or both axes to point to a different part of the sky, yet the mount will know where it is pointing. This is something that Sky-Watcher's previous mounts were unable to do.

We tested this freedom by first performing a star alignment and then using the handset to slew to the bright star Rigel in Orion. At the time of review, comet 2014 Q2 Lovejoy was to the lower right of this star, several degrees away, so we manually rotated the telescope to it. We then used the handset to return to Rigel, which it duly did. We performed similar tests in other parts of the sky with the same result, showing that the encoders do indeed do their job.

SINGLE ARM FORK MOUNT

The mount is sturdy and easily attached to the tripod via three bolts. There are ports for the hand controller and power from an external power tank, as well as a camera 'snap' port. The mount also features a battery compartment that can take eight AA batteries.

EYEPIECES AND BARLOW LENS

Two eyepieces (25mm and 10mm) and a 2x Barlow lens are supplied. The 25mm gave good wide-field views of objects such as the Sword of Orion, while the 10mm provided extra magnification for closer study. The Barlow was particularly useful for splitting close double and multiple stars.

HAND CONTROLLER

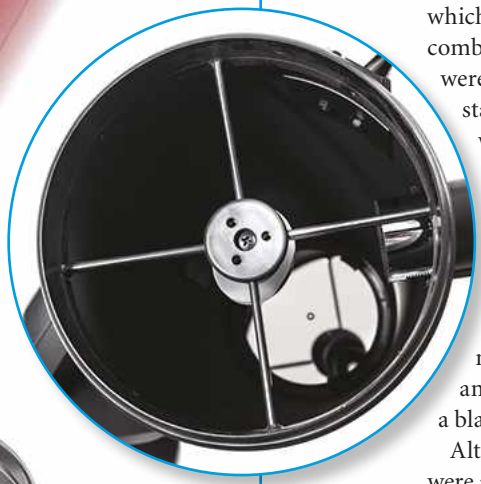
The hand controller supplied is the SynScan V4, which is a little larger than the SynScan V3 but possesses the same arrangement of buttons. It has a database of 42,900 objects, including the Messier, IC, NGC and Caldwell catalogues, as well as planets, named stars, double stars and variable stars.

TRIPOD

The stainless steel tripod is sturdy and can easily hold the combined weight of the mount and telescope. It can be adjusted for height and provides a good platform for the rest of the telescope to operate. It also includes a useful eyepiece tray.

FIRST **light**

SKY SAYS...
Now add these:
1. Power tank
2. GPS mouse
3. Planetary filter set



OPTICS

The parabolic 6-inch primary mirror has a focal length of 750mm, giving a focal ratio of f/5. Views were good, with pin-sharp stars visible across the central 75 per cent of the field of view through the supplied 25mm eyepiece, though there was some coma towards the field edges.

► **Though not intended for imaging, we were able to get a decent shot of the Moon using a DSLR**

► steady seeing we were able to glimpse the two fainter components of the Trapezium Cluster, which sits at the heart of the Orion Nebula. By combining the 10mm eyepiece and 2x Barlow, we were also able to split tight double and multiple stars – including triple star Iota Cassiopeiae, where the closest companion is only two arcseconds away from the primary star.

Using the 25mm eyepiece we could fit both members of galaxy pair M81 and M82 into the view, with the 10mm revealing a mottled edge on disc of the latter. The Crab Nebula, M1 in Taurus, was visible as a small patch of mist, while star clusters such as M44 in Cancer and M35 in Gemini appeared to sparkle against a black backdrop.

Although not designed for astrophotography, we were able to attach both an iPhone and a DSLR to the telescope (using our own adaptors) to capture a few shots of the Moon. With the DSLR we also had to use the Barlow lens in order to achieve focus, but overall we were pleased with the basic lunar images taken with the setup.

We found this an easy system to set up and use. It will give beginners a lot of fun discovering the wonders of the night sky. Tracking was generally good, with targets remaining close to the centre of the view for up to 20 minutes and only a small amount of drifting. Sky-Watcher has also incorporated its 'Freedom Find' technology into the mount, allowing you to swing it in either axis without it losing alignment, making it quite a versatile instrument. S

VERDICT

BUILD & DESIGN	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★½
GO-TO/TRACKING ACCURACY	★★★½☆
OPTICS	★★★½☆
OVERALL	★★★★½

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FIRST **light**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/altair72ED-R**

Altair Lightwave 72ED-R refractor

A grab and go instrument for those starting out in astronomy

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £369
- **Optics** ED glass doublet apo
- **Aperture** 72mm (2.8 inches)
- **Focal length** 430mm (f/6)
- **Focuser** 2.5-inch dual-speed 10:1 rack and pinion
- **Extras** Aluminium flight case
- **Length** 325mm with dew shield retracted, 385mm extended
- **Weight** 2.5kg
- **Supplier** Altair Astro
- **www.**altairastro.com
- **Tel** 01263 731505

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In an attempt to beat light pollution many astronomers travel away from their gardens to sites with darker skies, so there is much demand for high quality yet portable telescopes. Altair's Lightwave 72ED-R refractor aims to provide just that.

With its 2.8-inch aperture, relative lightness and diminutive size, this really is a grab and go telescope. It weighs just 2.5kg, placing minimal demands on small mounts. Better yet, it is supplied with a stylish aluminium case measuring just 39x25x19cm. Note, however, that it is not packaged with a star diagonal or any eyepieces.

The telescope tube's textured cream finish contrasts well with the unusual silver of the rack and pinion focuser, which has a 10:1 slow motion drive. Fit and finish are excellent, and should it ever be necessary the focuser can be collimated. Although it has is no lock, the extendable dew shield has a smooth friction fit that holds it in place even when pointing vertically.

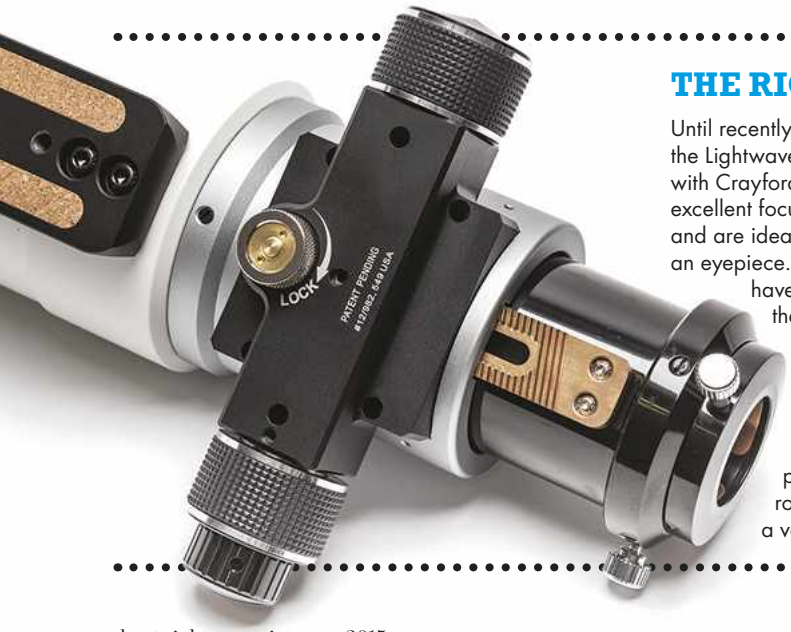
The focuser was smooth in operation and once locked in focus it held our relatively heavy CCD camera (1.66kg) with no slippage. However, focusing when using the 10:1 reduction knob required a combination of unlocking the tube clamp, making a small adjustment and then relocking before releasing the focus knob. Once locked, focus remained solid during our extended imaging sessions.

SKY SAYS...
We enjoyed using this scope as it is easy to operate and delivered memorable views

We were unable to obtain balance in the declination axis with our imaging equipment in place, as the built-in mounting foot was too short to allow adequate movement. However, we bolted the foot to our own Losmandy style dovetail bar using the two 1/4-20 tripod bushes set into the base of the foot, and this resolved the issue.

A wide field of view

The Lightwave 72ED-R's focal length of 430mm places it firmly into the wide-field category when it comes to imaging deep-sky objects. To put this into some kind of perspective, using a DSLR camera with its typical APS C sensor yields a field of view a fraction under 3° by 2°. This is enough to capture the entirety of the North America Nebula or the Veil Nebula in Cygnus. However, you can use a focal reducer-field flattener to correct field curvature, which will widen the field of view further. ▸



THE RIGHT FOCUSER FOR ASTRO IMAGING

Until recently, small refractors such as the Lightwave 72ED-R were supplied with Crayford focusers – which give excellent focus action with no backlash and are ideal for observations with an eyepiece. However, Crayfords do have an Achilles heel in that they are often not able to support the additional weight of photographic equipment reliably.

The Lightwave 72ED-R is supplied with a rack and pinion focuser that can be rotated and collimated, has a very smooth action, and yet is capable of supporting the weight of astrophotography equipment. This smooth and backlash-free system is achieved by the use of a helical gear system in which the teeth are set at an angle to the side of the gear, as opposed to being at right angles. This design increases the contact ratio (the number of teeth engaged), which in turn increases the load-bearing capability.

The substantial, baffled 2.5-inch focus tube has a very generous 97mm of movement with a 10:1 reduction drive, an etched scale and anti-marring eyepiece compression rings for both 2- and 1.25-inch eyepieces.

RETRACTABLE DEW SHIELD

The friction-fit retractable dew shield offers good protection from stray light. Its interior is finished in very matt black paint to keep reflections to a minimum and increase contrast. With an internal diameter of 85mm and an extension of 75mm in front of the primary lens, it also helps to reduce dewing.

ED GLASS DOUBLET

The lens in this telescope is an air-spaced doublet, one element of which is made from ED (extra-low dispersion) glass. With a focal length of 430mm, this f/6 doublet gives a wide field of view for both observing and astrophotography. The lens elements are fully multicoated to increase light transmission and reduce reflections.

CNC-MACHINED TUBE

The CNC-machined alloy optical tube is substantially made and finished in a textured cream powdercoat to a high standard. Internally, there are two light baffles and the whole inside is finished in matt black paint. A CNC-machined precision lens cell supports the front lens.

MOUNTING FOOT

This telescope doesn't have tube rings, instead relying on a fixed L-shaped foot with a Vixen-style dovetail profile incorporating two 1/4-20 threaded holes for use with a standard photographic tripod. In common with many similar telescopes, this was not long enough to allow proper balance adjustment with a camera attached.

FIRST **light**

▲ Though present, chromatic aberration was minimal indeed; this shot of the Pleiades open cluster in Taurus was captured with our own one shot colour CCD camera

▸ Early evening provided the best observing conditions during the review period and we enjoyed some great deep-sky views before the Moon made an appearance. The Ring Nebula in Lyra was tiny but perfectly visible, and the colour-contrasting stars that comprise the double of Albireo showed very nicely indeed. The Pleiades star cluster was a wonderful sight in our 17mm eyepiece at 25x magnification and star shapes remained good out to about 85 per cent of the field of view. A tiny amount of chromatic aberration was just visible on the Moon's limb but this was quite well controlled.

SKY SAYS...
Now add these:

1. Lightwave red-dot finder kit

2. Lightwave 1.0x field flattener for astrophotography

3. Altair 1.25-inch 99 per cent reflective dielectric star diagonal

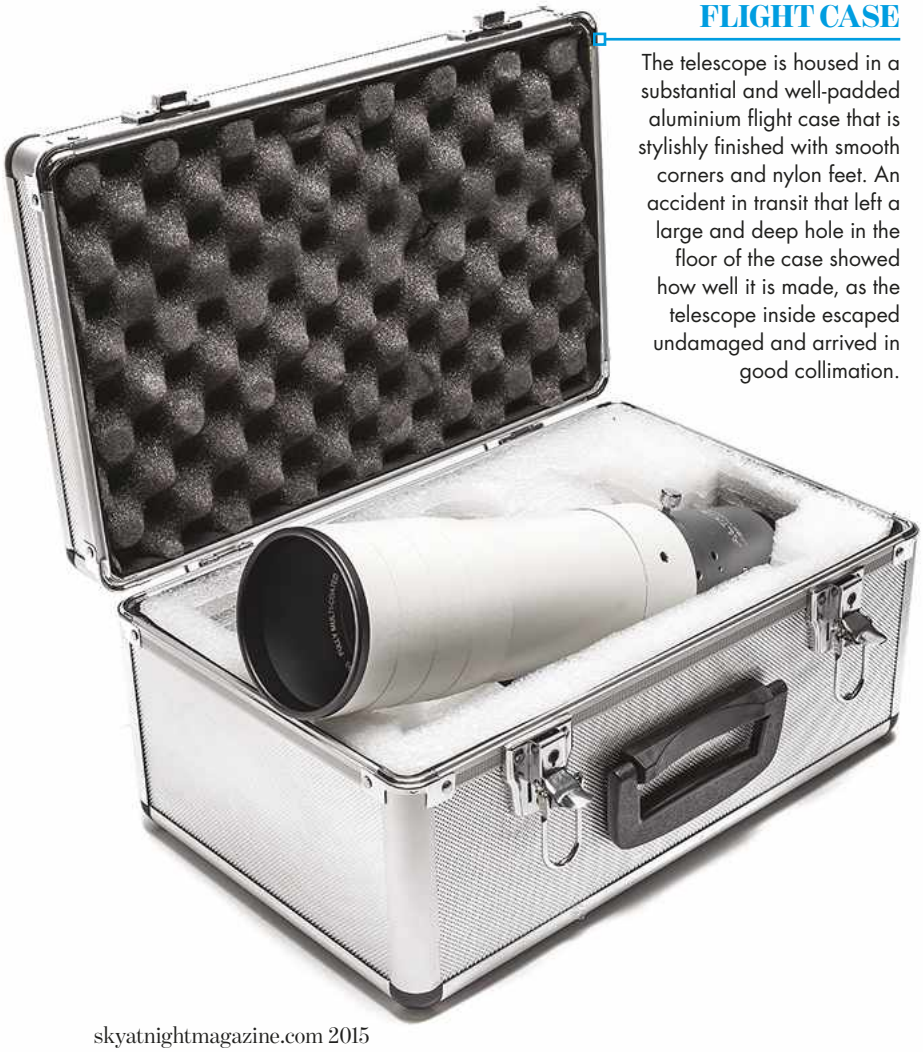
Fighting field curvature

Imaging the Pleiades with our own one shot colour CCD camera confirmed that chromatic aberration was minimal. In common with most refractors, we found the field curvature intrusive, resulting in elongated stars at the edges of the field of view of our shots. We also imaged the Eastern Veil Nebula in hydrogen-alpha, this time with our own focal reducer-field flattener to flatten the field: this delivered a good improvement, though it was still not perfect. Some vignetting was visible, but was resolved through image processing using a set of flat calibration frames.

We very much enjoyed using this telescope as it was easy to operate and delivered some memorable views. Its diminutive size, wide field of view, solid construction and good optics make it an excellent travelling companion, and its imaging capabilities only add to its usefulness. We would recommend the Lightwave 72ED-R as a grab and go instrument and to beginners starting out on their imaging journey. S

ALUMINIUM FLIGHT CASE

The telescope is housed in a substantial and well-padded aluminium flight case that is stylishly finished with smooth corners and nylon feet. An accident in transit that left a large and deep hole in the floor of the case showed how well it is made, as the telescope inside escaped undamaged and arrived in good collimation.



VERDICT

BUILD AND DESIGN	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★½
IMAGING QUALITY	★★★★½
OPTICS	★★★★½
OVERALL	★★★★½

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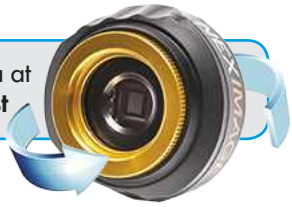
FIRST light

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/celestNIBurst**



Celestron NexImage Burst colour camera

A high-performance CMOS chip sets this Solar System imager apart

WORDS: MARTIN LEWIS

VITAL STATS

- **Price** £329
- **Sensor** Aptina ARO132 colour CMOS sensor
- **Pixels** 1,280x960 (3.75x3.75µm square)
- **Body dimensions** 48mm diameter, 26mm high
- **Weight** 29g
- **Extras** 1.25-inch to C-mount adaptor, USB lead, software CD
- **Supplier** David Hinds
- **www.**celestron.uk.com
- **Tel** 01525 852696

SKY SAYS...
This is a simple, well-performing camera that competes with the best in the market

▼ **'Diminuitive' doesn't do the NexImage Burst justice: it is a mere 48mm wide**

The NexImage Burst is the latest addition to a series of Solar System imaging cameras jointly developed between The Imaging Source (TIS) and Celestron. It is available as either a colour or monochrome camera and uses a 1,280x960-pixel CMOS imaging chip rather than the more traditional CCD chip. We're reviewing the colour version here, using both Windows 7 and Windows XP laptops for our tests.

When it comes to Solar System imaging, digital cameras are typically used to capture a series of videos, the best frames of which are then processed to create a single still image. This hugely reduces the blurring effects of our atmosphere and produces final images that show significantly more detail than any other method.

To capture the videos in the first place you need a software program that can control the camera. The one supplied with the NexImage Burst is iCap2.3, a generic TIS program capable of running a range of cameras. We found iCap to be rather idiosyncratic, with lots of unused buttons and sliders, greyed-out features and other quirks that could trip up consumers and affect the usability of their recorded videos. It is a pity that with 11 astronomy cameras now jointly produced by TIS and Celestron that they haven't come up with specifically tailored software. As an alternative to iCap, the camera can also be controlled using the latest beta version of the more user-friendly freeware program FireCapture.

Increasing the frame rate

One significant advantage of this camera over recent offerings from Celestron and TIS is that if you reduce the active area of the chip using the 'region of interest' setting you can now also benefit from an increased frame rate as well as the usual reduction in video file size. This is because the region of interest is now set in the camera rather than in the software.

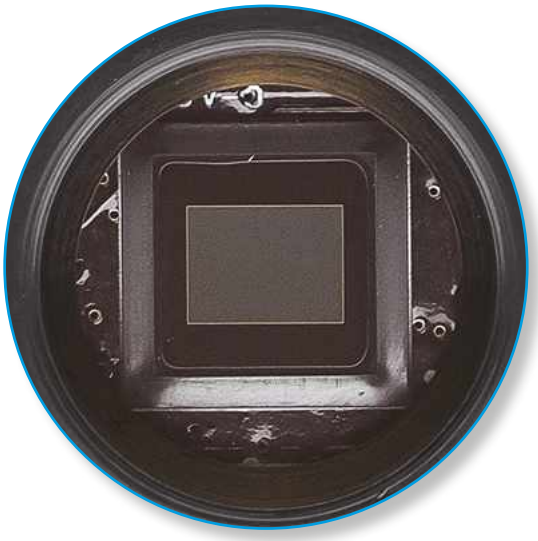
Adjusting the region of interest is useful for smaller targets such as the planets, as gathering more frames generally means more detail in the final image. Through this feature, the frame rate can rise from 25fps at the maximum imaging size of 1,280x960 pixels to a very rapid 197fps at the minimum size of 104x96 pixels.

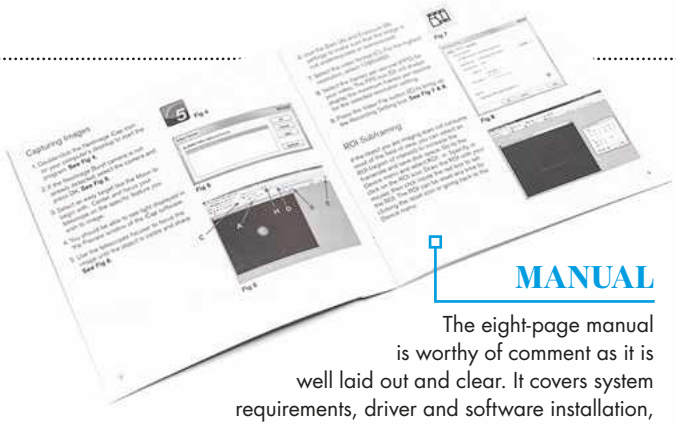
When focusing using a colour camera it is often helpful to preview the image in colour and you can do this with the dedicated iCap debayer toolbar button – do remember to turn it off before recording though, otherwise your best quality uncompressed (Y800) format video will not be usable. We did pick up an initial issue with the ▸

LOW NOISE, HIGH SENSITIVITY

Unlike the Skyris range of Celestron/TIS cameras, which use CCD chips, the NexImage Burst series possess Aptina ARO132 CMOS chips. CMOS chips used to be the noisier and less-sensitive cousins of CCDs, but recent advances in technology have moved CMOS chips on to the point where noise and sensitivity levels can be comparable or even better. In addition CMOS chips are faster and cheaper than CCDs and run at lower power.

The NexImage Burst's noise levels, even at maximum gain, were significantly less than those of a Sony 618 chip camera (currently the favoured CCD chip for Solar System imaging) and the sensitivity was slightly better, allowing us to capture more frames in a given time with less noise.





MANUAL

The eight-page manual is worthy of comment as it is well laid out and clear. It covers system requirements, driver and software installation, together with how to use the camera to capture videos and process them using RegiStax, which is also included on the CD. There are also some useful more general tips on digital video imaging.

USB CONNECTION

The camera possesses a USB 2.0 mini port and is supplied with a 1.2m USB lead, making it compatible with most laptops and computers.

APTINA CMOS COLOUR CHIP

As well as the benefits compared to many CCDs, the 1.2 megapixel CMOS chip in the NexImage Burst allows you to record in colour. Not having to record three separate videos through red, green and blue filters to later produce a colour image – as is the case with monochrome cameras – speeds up the imaging process considerably.

BODY

The camera has an attractive and tough-looking circular plastic body with an anodised C-mount metal coupling ring (in trademark Celestron orange) for a 1.25-inch adaptor. And at a very lightweight 29g, this camera is unlikely to upset the balance of your telescope.

FIRST light

1.25-INCH ADAPTOR

The 1.25-inch to C-mount adaptor screws onto the front of the camera, allowing you to insert it into an eyepiece holder. The barrel is threaded for filters. Though you won't need colour filters there are others you might use – such as an infrared-blocking filter, which can improve imaging quality.

▸ colour sliders having no effect on the colour balance of the Y800 recorded video, but this was fixed by downloading the latest driver from the Celestron website.

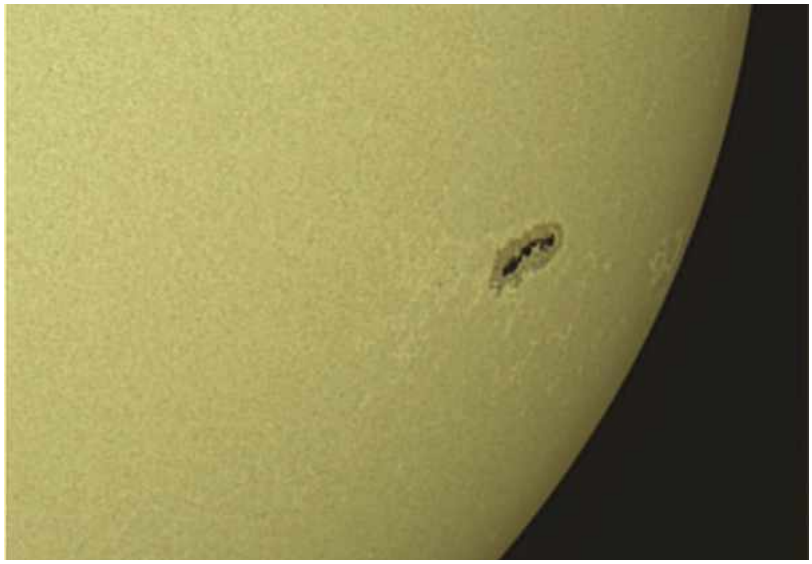
We tested the camera, attached to an 8.75-inch Newtonian, on Jupiter as it rose in the east. Correct exposure at medium gain only needed a 10-millisecond exposure, a testament to the high sensitivity of the CMOS chip. Using a region of interest of 464x396 pixels, we achieved a frame rate of 48fps. Noise levels were very low and even allowed a decent image with the gain set to maximum. No odd artefacts were seen on the processed planetary images at this frame rate, which was good news as this has been a problem in other planetary imaging cameras running at similarly high frame rates.

Aiming at the Moon and Sun

Targeting the Moon allowed us to use the whole area of the chip to good effect and produce nice smooth images at 1,280x960 pixels and 25fps. One downside for lunar imaging was the absence of a functional gamma setting in the iCap software, which would have allowed us to accommodate the wide brightness range in some of the higher contrast regions of the lunar surface.

The winter Sun was more of a challenge due to its low altitude, but with a white light solar filter attached to our telescope we again found the camera straightforward to use. We used to the whole chip again to cover a large area of the Sun, picking up details of a large sunspot near the limb as well as faculae and solar granulation.

With its 1,280x960 CMOS chip, the NexImage Burst is a simple, well-performing camera that competes with the best digital video cameras on the market. It should enable you to take great images of planets, Sun and Moon. S



▲ Adding a white light filter to our scope allowed us to capture this sunspot and solar granulation

▲ Our shot of the Mare Crisium at 1,280x960 pixels and 25fps

◂ We found no artefacts in our image of Jupiter at 464x 396 pixels and 48fps

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EASE OF USE	★★★★½
FEATURES	★★★★½
IMAGING QUALITY	★★★★★
OVERALL	★★★★★

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All prices correct at time of press. Subject to change. Errors and omissions excepted.

Books

New astronomy and space titles reviewed

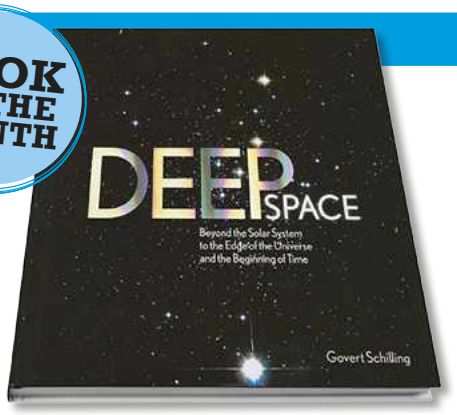
RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

You can order these books from our shop by calling 01803 865913

Deep Space

BOOK OF THE MONTH



Govert Schilling
Black Dog & Leventhal Publishers
£19.99 ● HB

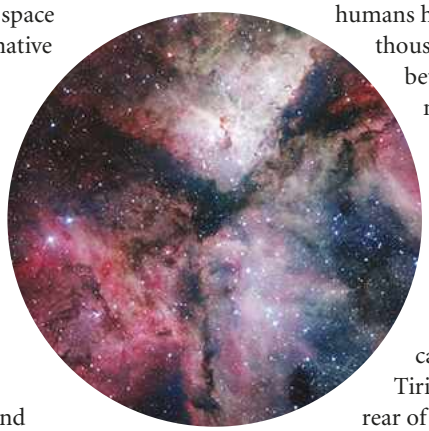
Deep Space is a ticket to ride on a sightseeing trip across the cosmos, visiting key locations en route to the beginning of space and time. Our guide is Govert Schilling, a renowned populariser of science with a gift for conveying awesome concepts to ordinary Earthlings.

Passports are included, though in this case they are panels listing key facts about the individual stops on our grand tour; our picture postcards are the many spectacular images of the heavens, some of them photos taken with space telescopes, others imaginative artists' concepts.

The tour of the Universe begins in the Solar System, starting with the Sun, then the planets grouped as rocky and gassy worlds. Separate stops clump together the moons of the other planets and other lesser bodies, such as comets and asteroids. Sadly the Rosetta mission's superb close-ups of a comet 67P Churyumov-Gerasimenko came too late to be included, and neither is room found for a photo of Pluto, following the loss of its planetary status.

Beyond the Solar System, our tour takes us to newly found exoplanets, clusters and nebulae, and then out to the galaxies. There are pauses on the way to give us a background in the history of astronomy and the vehicles that allow us to make our virtual voyage, telescopes both on the ground and operating in the depths of space.

There is much ground – or rather Universe – to cover in this whistle-stop race through space. But alongside the hundreds of illustrations, Schilling's highly readable and authoritative text ensures no one gets lost. As well as a voyage through space we come to appreciate the journey humans have taken over thousands of years to better understand the nature of their cosmic surroundings.



***Deep Space* explores the marvels of nebulae, clusters and more**

Though not a book about amateur astronomy, there are 14 pages of star charts by famed celestial cartographer Wil Tirion towards the rear of the book. Though they are few, like any good guide they help us to locate the positions of the sights featured in the heavens, while reminding us that the only way we can really ever visit them is with our feet planted on planet Earth.

★★★★★

PAUL SUTHERLAND *is a space writer and journalist*

Reader price £17.99, subscriber price £16.99
P&P £1.99 Code: S0315/1 (until 24/04/15)

TWO MINUTES WITH GOVERT SCHILLING

What inspired you to write the book?
I remember astronomy books from the 1970s, when just a handful of nebulae, star clusters and galaxies had been photographed in colour with the 5m Hale Telescope at Palomar Mountain, at a quality that is now regularly surpassed by amateur astronomers using CCD cameras. You could also say that the inspiration for the book came from the fact that astronomy has become such a 'visual' science.

What is deep space?
In a sense, everything beyond Earth's atmosphere is deep space. But more typically it's a phrase that has been used by observational and amateur astronomers alike for extended objects beyond the Solar System. I decided to provide a brief introductory section on the Sun and the planets, but the emphasis is really on the objects in our Galaxy and the wider Universe.

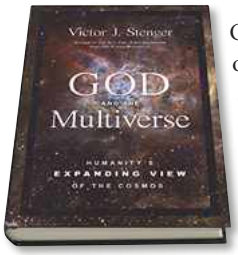
Why is deep space so fascinating?
What is most fascinating to me personally is the interconnectedness of everything in the Universe. A century ago, we had hardly any clue about nebulae and galaxies. But today, we know how all these objects fit into the big cosmic jigsaw puzzle of the expanding Universe, the large-scale structure of clusters and galaxies, the formation of stars, stellar nucleosynthesis, and the origin of planets and life. Astronomy has given us a thought-provoking picture of our place in space and time.

GOVERT SCHILLING *is an award winning astronomy writer*

ESO. ACKNOWLEDGEMENT: VPHAS+ CONSORTIUM/CAMBRIDGE ASTRONOMICAL SURVEY UNIT

God and the Multiverse
Humanity's Expanding View of the Cosmos

Victor J Stenger
Prometheus Books
£19.99 ● HB



Could there be countless other universes out there alongside our own? If a multiverse exists, can it be explained by science, or do we need intelligent design?

These questions frame *God and the Multiverse*, the newest and sadly last book from the late particle physicist Victor J Stenger, who passed away in 2014. Religion crops up often in Stenger's 12 other books, with past titles including *God: The Failed Hypothesis* and *God and the Atom*.

The book journeys through ancient mythology, medieval cosmology, particle physics, relativity, quantum mechanics, the Big Bang theory, inflation, dark matter… you name it, it's covered here.

It's only towards the end of the book that we find chapters on the topics mentioned in its title – multiverses and religion's role in astronomy – so it seems mismatched to the content. Indeed, religion is not a major theme here: this is more of a journey through particle, quantum and astrophysics from the beginning to present day. It fulfils this brief very well, with a comprehensive timeline-like structure.

At times it is dense; some chapters are peppered with equations and particle diagrams, and so many names are thrown around that it can be difficult to remember what they refer to. This is a hazard of any book of this type and Stenger deals with it reasonably well. While it may not be exactly as billed on the cover, *God and the Multiverse* covers a huge amount of material in a readable and well-explained way.

★★★★☆

NICKY JENNER *is a science journalist and Hubble public information officer*

Reader price £17.99, subscriber price £16.99
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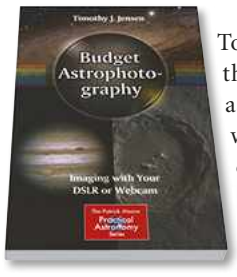
Budget Astrophotography

Timothy J Jensen
Springer
£16.99 ● PB



To many amateurs, the idea of 'budget astrophotography' will sound like a contradiction in terms. Astro imaging has a reputation for being very expensive.

In this book, Timothy J Jensen seeks to cover several disciplines – deep sky, solar, lunar and planetary imaging using both DSLR cameras and webcams – so there should be something for everyone starting out on their imaging journey.

Jensen's first chapter covers how digital cameras work and gives a good grounding on the significance of sensor size and characteristics. The second discusses telescope basics and again is useful, but it was disappointing to see that the refractor light path diagram showed an instrument that would be impossible to use for prime focus imaging. Mounts and polar alignment follow, but this chapter morphs into a further discussion on cameras that would have been better off in the first chapter.

DSLR image capture and calibration follow next and here the author gets into his stride, with engagingly written sub-sections leading onto image processing for deep-sky objects and the Moon.

Subsequent chapters include planetary imaging with a webcam, spectroscopy, astrometry and advanced image processing. There are also around 55 pages of images with a list of the equipment used for each; these are attractive but contribute little to the learning process.

Overall, this book is not very cohesive but there is some good information buried within the pages to help a beginner make a start in each of the disciplines without spending a fortune.

★★★☆☆

STEVE RICHARDS *is* BBC Sky at Night Magazine*'s Scope Doctor*

Reader price £14.99, subscriber price £13.99
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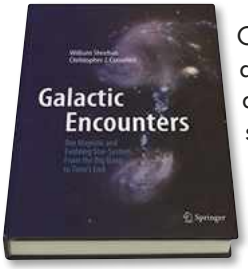
Galactic Encounters

William Sheehan and
Christopher J Conselice
Springer
£32.99 ● HB



Co-written by an astronomy historian and a galaxy specialist, *Galactic Encounters* tackles four centuries of discovery from an astronomer's point of view. Starting with Galileo's realisation that the Milky Way is actually composed of a huge number of individual stars, we learn about the lives and achievements of those who probed the secrets of not just our own Galaxy but those beyond. Among those featured are the catalogue of Charles Messier, the star-gages (star counts) of William Herschel and the revolutionary observations made using the 72-inch Leviathan of Parsonstown.

We are subsequently taken to the dawn of the 20th Century and the tireless efforts of George Ellery Hale to push back the frontiers of observational astronomy, which eventually led to the emergence of the first great reflecting telescopes of the modern era. As instrument size and capability grew, our understanding of our own Milky Way expanded, as did that of the seemingly limitless number of galaxies throughout the cosmos.

The book describes the visionary efforts of great observers such as Barnard, Hubble, Humason and Morgan, their pioneering accomplishments eventually followed by the advent of modern space telescopes. Written to suit the layperson, *Galactic Encounters* presents the reader with a lucid account of our growing understanding of the nature and formation of galaxies, and their place in the Universe.

★★★★★

BRIAN JONES *has written 15 books on astronomy and space*

Reader price £29.99, subscriber price £27.99
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Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1 Mobile Observatory App

Price £3.90 • **Supplier** Wolfgang Zima
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One of the most complete astronomy apps for Android, Mobile Observatory allows you to keep track of comets, lunar eclipses, conjunctions and more. Features include zoomable sky maps and star catalogues.

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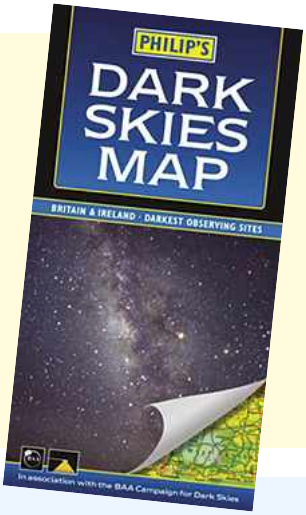

5 Keep Calm Mug

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6 Moon Phases T-Shirt

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Whatever phase the Moon is in outside this T-shirt will match, as it shows off our nearest neighbour through a complete lunar cycle.

WHAT I REALLY WANT TO KNOW IS...

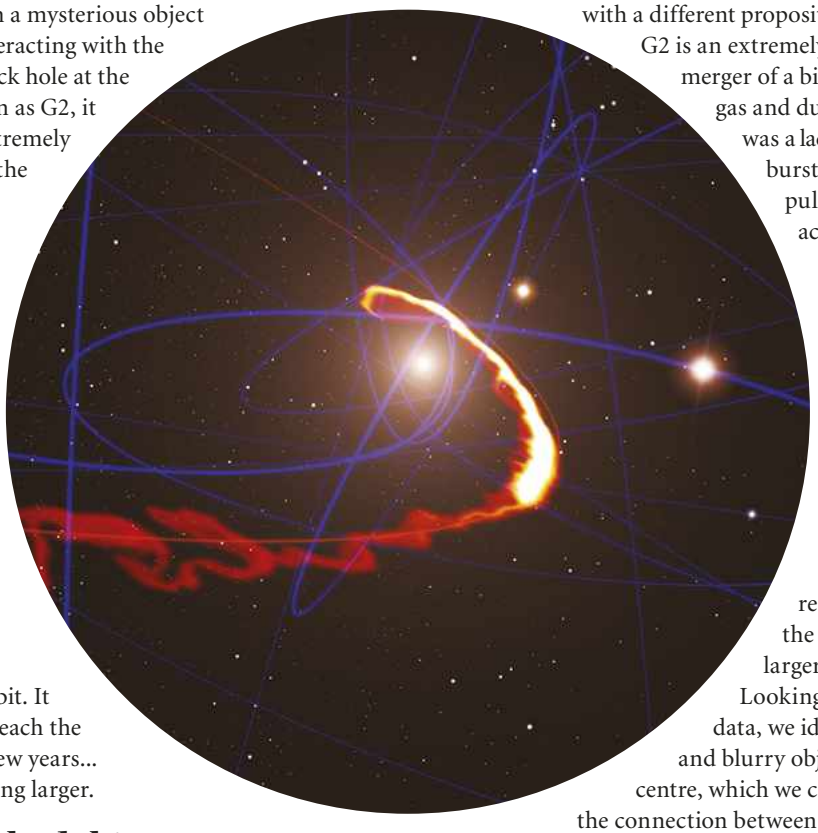
What is circling our Galaxy's black hole?

Stefan Gillessen is studying a stretched-out stream of gas wrapped around the singularity at the centre of the Milky Way

INTERVIEWED BY PAUL SUTHERLAND

For the past couple of years there has been a lot of interest in a mysterious object that has been interacting with the supermassive black hole at the heart of our Galaxy. Known as G2, it appears to have become extremely stretched and distorted by the black hole, but its nature is still controversial.

I am part of the team that discovered this strange object. In 2011 we were looking at images taken by the VLT in 2002 when we saw an apparently cool object (300°C compared to stellar surfaces of thousands of degrees) approaching the black hole quickly. It was rather faint, but our imaging and spectroscopic observations allowed to determine its orbit. It was obvious that it would reach the closest approach within a few years... and that it was also becoming larger.



First it was thought G2 was a single cloud; Gillessen now suggests it could be part of a much longer gas streamer

A mystery stretched thin

Our studies showed it becoming spaghettified, stretched over more than 160 billion km around the closest point of its orbit around our local black hole, which is known as Sgr A*. Its closest approach would take it to just over 25 billion km from the black hole itself – barely escaping from falling right in. The cloud is so stretched that the closest approach is not a single event, but rather a process that extends over a period of at least one year. It still takes a finite amount of time, but the situation is more like a train passing by.

The discovery sparked huge interest, and an array of ground and space scopes has been trained on the region to watch, for the first time, as an object is tidally torn apart by its encounter with Sgr A*, which is around four million times more massive than the Sun, and an object becoming tidally torn apart by it. We concluded that G2 was a cloud of hydrogen gas and dust that is being ripped to shreds by the black hole. Watching what happened to it has helped us learn how these cosmic monsters feed on material that is drawn towards them.

Last year, another team of astronomers came up with a different proposition. They suggested that G2 is an extremely large star, formed by the merger of a binary pair, and cloaked in gas and dust. Part of their reasoning was a lack of 'fireworks', or X-ray bursts, as material from G2 was pulled onto the black hole's accretion disc.

But no models for what would happen to G2 suggested it would lose material faster in 2014 – that would only come later. So the absence of any fireworks now is not telling us much, and I am sceptical of the new merged star model.

Our own ongoing research has shown that the gas cloud may be much larger than we first thought. Looking again at decade-old data, we identified another faint and blurry object close to the Galaxy's centre, which we called G1. We explored the connection between G1 and G2 and found an astonishing similarity in both orbits; this is highly plausible evidence that G1 and G2 are part of the same gas streamer. We also see gas following G2 on another very similar orbit – perhaps this streamer will develop into G3 or even G4 in the future, and perhaps G2 is just one knot in a much longer gas stream.

Watching what happens to this gas cloud will help tell us how the supermassive black hole's surroundings, or 'atmospheres', are structured. From the amount of friction the cloud experiences, we can estimate how much gas there is and so learn how such an atmosphere is made.

Another part of the mystery of G2 is where the cloud of gas originally came from. We believe that it, and G1, could have been born as clumps in the stellar winds streaming from one of the massive stars at the centre of the Galaxy, or in the collision between winds from several of these stars. Alternatively it might be the gaseous debris left over when an unlucky giant star lost part of its atmosphere a few hundred years ago.

ABOUT STEFAN GILLESSEN

Dr Stefan Gillessen is based at the Max-Planck-Institute for Extraterrestrial Physics at Garching, Germany. From there he investigates the nature of the supermassive black hole at the heart of the Milky Way.

Astronomy at Herstmonceux

The Observatory Science Centre is home to some of the largest telescopes in the UK and offers astronomy evening courses, open evenings with public viewing, plus an annual astronomy festival.

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PHOTO: JOHN FOX

UK Retailer Guide

Find the right one for you: buy your telescope from a specialist retailer

It is quite easy to become daunted by the vast array of equipment that is available to today's amateur astronomers. Different makes, different models, different sizes and optical arrangements – if you're new to the hobby, how do you make sense of all these details and find the telescope that will show you the Universe?

The answer lies in buying from a specialist retailer – somewhere that really knows what they're talking about. Like the retailers in this guide, they'll have the practical knowledge that will guide you towards the scope that won't end up gathering dust in a cupboard.

Today there are over 1,000 models of telescope to choose from – refractors and reflectors, Dobsonians and Newtonians, Schmidt- and Maksutov-Cassegrains. And just as important as the telescope is the mount it sits on; but do you go for equatorial or altazimuth, manual or Go-To? And what about accessories like eyepieces and finderscopes?

That's certainly a lot to consider before making a decision, but a specialist retailer will help you make that decision, taking important considerations like portability, construction and price into account.

So if you need friendly, face-to-face advice and excellent aftersales service, free from biased opinions, specialist telescope retailers are the place to go for a helping hand through the technical literature and tables of figures. They'll help you find a scope that combines quality and convenience at a price that's right.

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Founded in 1785, Telescope House has been responsible for supplying many well-known Astronomers with telescopes and equipment. The late Sir Patrick Moore bought the majority of his telescopes from the company, including his very first instrument. With a friendly showroom in Surrey, a number one ranked retail website and a service centre with fully qualified staff, the company offers equipment from manufacturers such as Meade, Revelation, Coronado, Bresser, Skywatcher, Orion USA, TeleVue, Vixen and Explore Scientific. Whether it's advice on your first telescope, to setting up advanced Astrophotography systems, the staff at Telescope House have a wealth of experience and instant access to the right stock to back it up.

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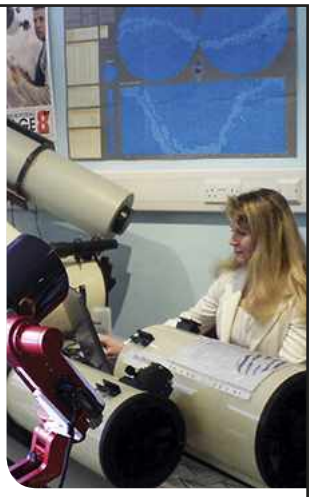

The Widescreen Centre

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The Southern Hemisphere in March

With Glenn Dawes

WHEN TO USE THIS CHART

1 MAR AT 00:00 UT
15 MAR AT 23:00 UT
31 MAR AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

MARCH HIGHLIGHTS

The Moon has some impressive conjunctions. In the early morning hours of the 13th it forms a triangle with Saturn and mag. +1.1 Antares (Alpha (a) Scorpii), and during twilight on the 22nd it lies between Venus and Mars.

The Gamma Normid meteor shower is active from 25 February to 28 March, with peak activity expected around the 15th. Although it has a low zenithal hourly rate, its meteors are renowned for being bright.

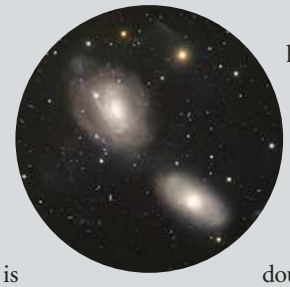
STARS AND CONSTELLATIONS

The ship Argo Navis sails high in the southern evening sky, of course better known today as the constellations of Carina (the Keel), Puppis (the Stern) and Vela (the Sails). Two nearby, lesser-known constellations have been loosely connected with, but were not part of, the original Argo: below (south of) the keel lies Pisces Volans, the Flying Fish, in modern times shortened to just Volans. It consists of six scattered 4th-magnitude stars. North of the Sails lies a similar grouping: Pyxis, the Compass.

THE PLANETS

Venus is low in the western sky and sets near the end of twilight. Mars is to the lower left of Venus, the separation gradually widening from 3° to 16° at month end. Jupiter is in the northern sky and best seen in the evening, while Saturn is best placed in the morning; look due north around dawn. Mercury becomes a dawn object from mid-month. This month the Sun is between the two outer planets. With Neptune rising out of the morning glare and Uranus vanishing into the evening twilight.

DEEP-SKY OBJECTS



Obscure constellation Sextans is located south (above) Leo. A good way to find its mag. +4.5 alpha star is to look 12° directly south of mag. +1.4 Regulus (Alpha (α) Leonis). Two-thirds of the way along is galaxy pair NGC 3166 and 3169 (RA 10h 14.2m, dec. +03° 28'; pictured). These two similar, 10th-magnitude spirals are only 8 arcminutes apart, easily fitting into most eyepiece fields. Both show oval hazes approximately 4x2 arcminutes with bright nuclei. NGC 3169 is east-northeast of its companion.

Only 7° east-northeast of these galaxies is double star 35 Sextantis (RA 10h 43.3m, dec. +04° 45'). Its components are mag. +6.2 and +7.1, separated by 6.6 arcseconds. The primary is orange, but the colour of the second is debated: suggestions range from pale blue to orange again.

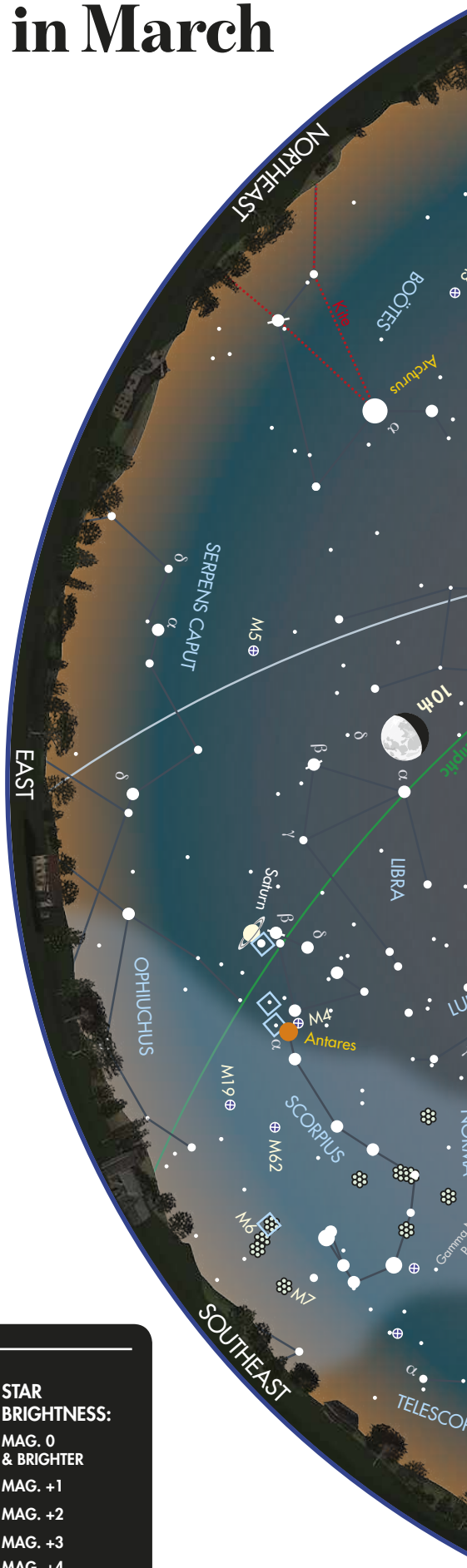
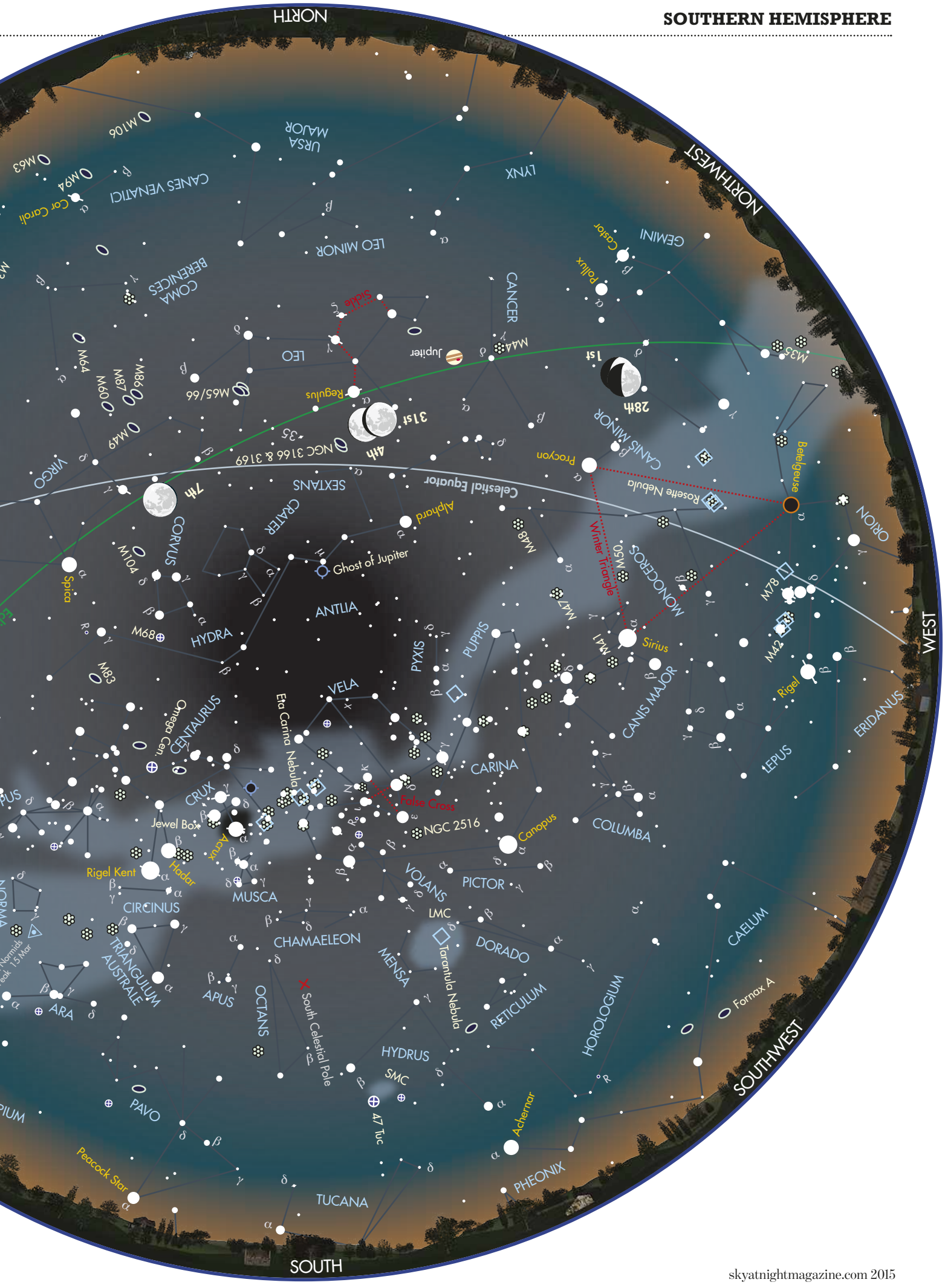


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE) AND H. SCHWEIKER (WIYN AND NOAO/AURA/NSF)


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Celestial Equator
Ecliptic
URSA MAJOR
CANES VENATICI
LYNX
GEMINI
LEO MINOR
COMA BERENICES
CANCER
LEO
VIRGO
CRATER
CORVUS
SEXTANS
HYDRA
ANTLIA
CANIS MINOR
ORION
MONOCEROS
PUPPIS
PYXIS
VELA
CENTAURUS
CRUX
CARINA
CANIS MAJOR
LEPUS
ERIDANUS
COLUMBA
VOLANS
PICTOR
CIRCINUS
MUSCA
CHAMAELEON
TRIANGULUM AUSTRALE
APUS
OCTANS
MENSA
DORADO
CAELUM
RETICULUM
HOROLOGIUM
HYDRUS
PAVO
TUCANA
PHOENIX
Jupiter
Regulus
Spica
Alphard
Ghost of Jupiter
Procyon
Betelgeuse
Rosette Nebula
Winter Triangle
Sirius
Rigel
Eta Carina Nebula
False Cross
NGC 2516
Canopus
Jewel Box
Acrux
Hadar
Rigel Kent
Omega Cen.
Tarantula Nebula
South Celestial Pole
SMC
LMC
47 Tuc
Achernar
Peacock Star
Fornax A
Cor Caroli
Sickle
Pollux
Castor
1st
28th
31st
4th
7h
M106
M63
M94
M64
M65/66
M86
M87
M60
M49
NGC 3166 & 3169
M44
M35
M48
M50
M47
M41
M78
M42
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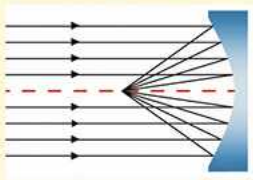

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